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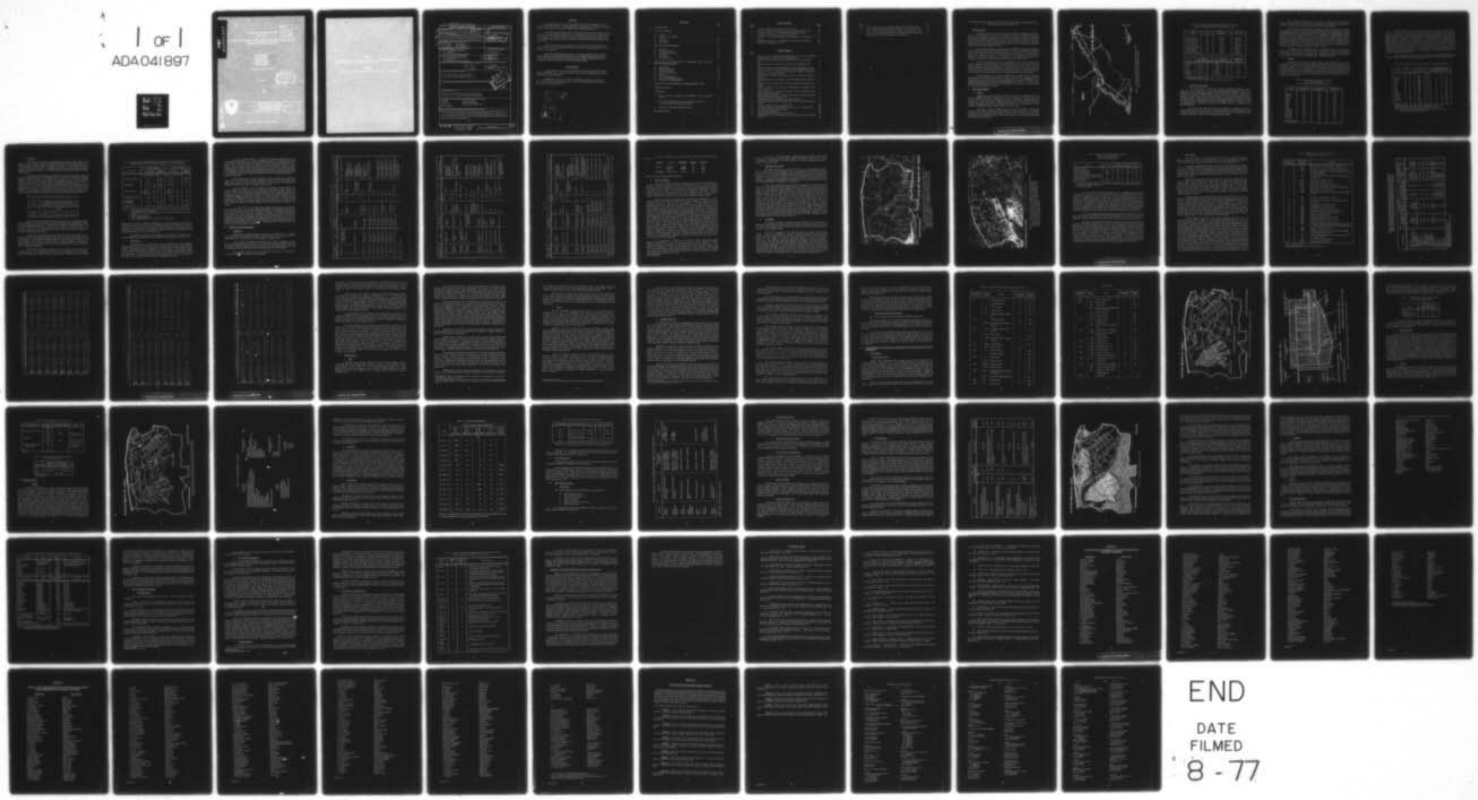

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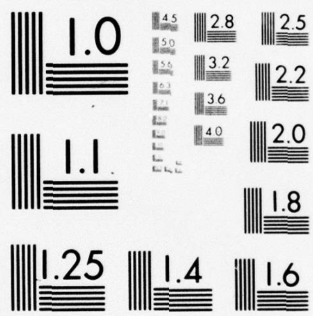

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PRELIMINARY ENVIRONMENTAL SURVEY OF HOLSTON ARMY AMMUNITION PLANT, KINGSPORT, TENNESSEE, APRIL 1976

by

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June 1977

DEPARTMENT OF THE ARMY
US Army Armament Research and Development Command
Chemical Systems Laboratory
Aberdeen Proving Ground, Maryland 21010

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A preliminary environmental survey was conducted at Holston Army Ammunition Plant (HAAP) in April 1976. This report presents the data compiled from that visit and a thorough literature search of regional sources. The actual or potential environmental impact of operations performed at HAAP is discussed. Biological data gaps have been indicated and the potential occurrences of rare or endangered species have been discussed and documented where this information is available.

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PREFACE

The work described in this report was authorized under Task 2, Subproject 3, PAA Project 57X4114, Development of Methods to Minimize Environmental Contamination; Ecological Surveys of Environmental Conditions at USAMC (now DARCOM) Installations.

In conducting such ecological surveys, a three-phase program has been developed. Phase I (initial site visit) was completed in March 1976. The publication of this report completes phase II of this program. The design of phase III (ecological surveys) will be based on the results of this report, although phase III work will not be conducted at Holston Army Ammunition Plant under this program.

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Special thanks are also given to Mrs. Jane Dierdorff for preparing the artwork, to Dr. F. Prescott Ward for proofreading the paper, and to Mrs. Phyllis Schultz and Ms. Michele Duerbeck for typing the manuscript.

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PRELIMINARY ENVIRONMENTAL SURVEY OF HOLSTON ARMY AMMUNITION PLANT, KINGSPORT, TENNESSEE, APRIL 1976

I. INTRODUCTION.

In response to public concern for environmental quality, the President, the Congress, and State and local legislative bodies have issued stringent directives to ameliorate the declining health of the environment. In response to these directives, the US Army Materiel Development and Readiness Command (DARCOM) has initiated major programs in pollution control and abatement which involve many scientific disciplines, including biological sciences. Consequently, biological assessments of pollution control and abatement are now being used to insure that the environment is not being deleteriously affected.

In conducting assessments at the direction of DARCOM, the Ecological Research office has developed a three-phase approach: (1) initial site survey, (2) preliminary environmental survey, and (3) ecological surveys. The objectives of this publication are to collate and to evaluate data pertaining to the area in which Holston Army Ammunition Plant (HAAP) is located, the mission and activities of the installation, an environmental description of the installation, and potential environmental impacts from installation-related activities.

This document provides a basis for determining the critical activities of HAAP which are now affecting environmental quality. Current information about the activities and their effects is evaluated, and recommendations for additional work are made in areas where the existing information is incomplete or insufficient to determine the impact of particular activities on the biota and environment of HAAP. The document also provides a detailed list of references and other sources from which additional specific and detailed information can be obtained.

This survey program was initiated at Holston Army Ammunition Plant on 1 March 1976. Phases I and II will be completed with this report. Plans to initiate ecological surveys at HAAP will not be developed until the current toxicology and field surveys of RDX/HMX (cyclotrimethylenetrinitramine/cyclotetramethylenetetranitramine) are completed by the US Army Medical Research and Development Command, Fort Detrick, Maryland. However, recommendations for surveys in specific areas are included.

II. AREA DESCRIPTION.

A. General.

Holston Army Ammunition Plant is located in Sullivan and Hawkins counties. This area in northeastern Tennessee is bounded on the east and southeast by Johnson and Carter counties, on the south by Greene and Hamblen counties, on the west by Grainger and Hancock counties, and on the north by the Tennessee-Virginia State line (figure 1). The total land area comprises 907 square miles (table 1). Kingsport, the nearest city, is approximately 165 miles northeast of Chattanooga, within a nearly continuous mountain chain.

The area is sparsely populated with the greatest demographic concentrations occurring in the tri-city area (Johnson City, Kingsport, and Bristol). This area is the economic, educational, and social region which HAAP potentially affects. Statistical facts have been summarized from a 30-mile radius (table 1) because it includes the area from which HAAP draws more than 90% of its employees.

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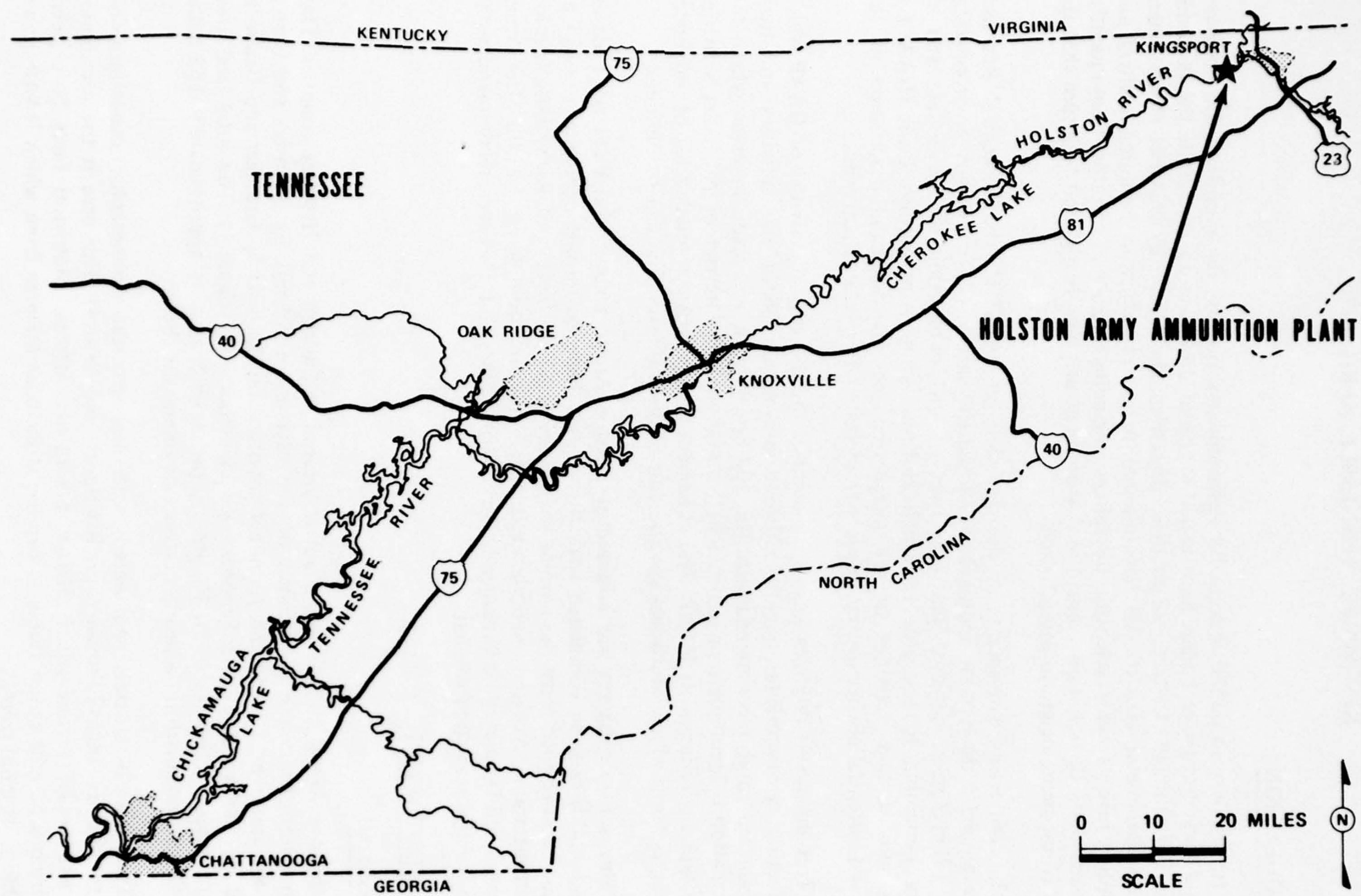


Figure 1. Location of Holston Army Ammunition Plant, Area B

Area A is located west of route 23 in Kingsport, Tennessee.

Table 1. Summary of the Geographical and Population Data for the Area Within a Thirty-Mile Radius of Holston Army Ammunition Plant

County	Area sq mi	Population*	County seat
Sullivan (Tennessee)	427	129,500	Blountville
Greene (Tennessee)	613	49,400	Greeneville
Unicoi (Tennessee)	185	15,254	Erwin
Carter (Tennessee)	348	42,575	Elizabethton
Washington (Tennessee)	323	78,300	Jonesboro
Hawkins (Tennessee)	480	37,400	Rogersville
Scott (Virginia)	539	25,290	Gate City
Washington (Virginia)	574	40,133	Abingdon

County	Population		Population		Population per square mile
	Urban	Percent total	Rural	Percent total	
Sullivan**	71,037	55.8	56,292	44.2	308.1
Greene	13,722	28.8	33,908	71.2	77.7
Unicoi	7,232	47.4	8,022	52.6	82.5
Carter	12,269	28.8	30,306	71.2	122.4
Washington	33,770	45.7	40,154	54.3	228.5
Hawkins	9,918	29.4	23,808	70.6	70.2

*Census of 1970 World Almanac. 1975.
**Tennessee Statistical Abstract. 3d Edition. University of Tennessee, Knoxville. 1974.

B. Topography and Drainage.

The A and B plants of HAAP are contained in Sullivan and Hawkins counties, respectively. These counties lie in two provinces of the Appalachian Highlands: the Valley and Ridge province and the Blue Ridge province. The Blue Ridge province includes the Holston River Mountains with elevations 3,000 to 4,000 feet above sea level. The mountains of this chain are generally steep-sided, massive peaks with narrow ridges. The remaining area described as Valley and Ridge province is rolling land with numerous intermountain ridges to 2,000 feet. The Ridge and Valley province is subdivided into five major physiographic divisions, according to the relief and underlying rock. Two divisions are included in the HAAP vicinity, the western shale hills and Bays Mountain.[1]

The western shale hills extend northeast and southwest of Kingsport. The elevation averages about 150 feet higher than that of the limestone ridges and valleys. Drainage channels thoroughly dissect the area and both the north and south forks of the Holston River have modified the topography. Relief is characteristically hilly and knobby.

Bays Mountain predominates the area and it is south of the Holston River. Elevations are about 2,200 feet above sea level or 1,000 feet above Kingsport, which is located at the base of Bays Mountain on the bottoms and terraces of the Holston River.

Both forks of the Holston River are somewhat shallow and sinuous. They carry the major drainage of the area to the Tennessee River. The North Fork of the Holston flows south from Saltville and Gate City, Virginia. The two forks converge at the north boundary of HAAP "B" plant. Upstream of Kingsport, the South Fork is impounded by Fort Patrick Henry Dam, a hydroelectric and flood control project of the Tennessee Valley Authority (TVA). Prior to construction of the dam, flooding was common. TVA is required to release enough water from the Fort Patrick Henry Dam to maintain the flow at 450 ft^3/s to meet the industrial needs of Kingsport for cooling waters. Now, the current demand is over 750 ft^3/s, so additional water is purchased, principally by Tennessee Eastman Company, from TVA.

The North Fork of the Holston River is not regulated and has an average flow of 851 ft^3/s and a 20-year 5-day low flow of 46 ft^3/s. Tennessee water quality criteria are applied on the basis of two definitions of minimum flow: (1) unregulated streams - 3-day minimum, 20-year recurrence interval, and (2) regulated streams - instantaneous minimum.[2]

C. Climate.

The climate in the vicinity of HAAP is highly variable (although it is characterized as temperate and continental) with short, moderate winters and long, warm summers. Lowest temperatures usually occur in the mornings during short periods of inversion. Prolonged periods of cold weather in the area are generally due to slow-moving cold cells associated with storm centers from Pennsylvania and southern New York. Monthly mean temperatures range from 36°F in January to 75°F in July (table 2). The growing season consists of about 180 frost-free days between April and October.[1]

Table 2. Average Temperature Extremes for the Holston Army Ammunition Plant Area
Normals are based on record for the 1941-1970 period.[3]

Month	Daily maximum	Daily minimum	Monthly mean
	°F	°F	°F
January	46.0	26.7	36.4
February	48.9	28.4	38.7
March	57.1	34.5	45.8
April	68.3	44.2	56.3
May	77.1	52.6	64.9
June	84.0	60.7	72.4
July	85.9	64.4	75.2
August	85.3	63.1	74.2
September	80.4	56.6	68.5
October	70.4	45.3	57.9
November	56.9	34.5	45.7
December	47.3	28.0	37.7
Yearly average	67.3	44.9	56.1

Although HAAP does not lie within any principal storm tracks, it comes under the influence of storm centers that pass along the gulf coast and up the Atlantic coast toward the northeast. Topography is quite important in causing weather patterns peculiar to this area. Moist easterly airflow in the lower levels of the atmosphere is usually blocked by the eastern mountain slopes, producing an abundance of precipitation on the higher ridges but leaving only dry, slightly warmer air masses for the Holston area. July has the greatest precipitation from thunderstorms occurring most frequently in the afternoon and early evening. In late winter, rainfall is also abundant, due mainly to moist air associated with storm centers to the south and northeast. Average annual precipitation is over 40 inches, but 80 inches annually has been recorded in some mountainous sections to the east and south.[3] Snowfall accumulations persist in mountainous regions after November.

The average windspeed is 5.6 miles per hour (table 3).[3] Surrounding mountains tend to enclose HAAP and Kingsport and thus direct airflow along the course of the Holston River.

Table 3. Wind Characteristics (Averages) for the Holston Army Ammunition Plant Area

Month	Average speed	Prevailing direction	Maximum windspeed*		
			Speed	Direction**	Year
	mph		mph		
January	6.4	WSW	40	25	1965
February	7.0	NE	46	25	1961
March	7.5	WNW	40	25	1952
April	7.2	WSW	40	25	1970
May	5.4	WSW	50	32	1951
June	4.6	NE	35	26	1973
July	4.1	WSW	40	23	1961
August	3.8	NE	46	34	1962
September	4.3	NE	29	31	1967
October	4.6	NE	35	28	1965
November	5.9	W	35	29	1965
December	6.0	WSW	40	24	1968
Yearly average	5.6	WSW	50	32	1951

*Maximum windspeed – Speed in miles per hour observed during a 1-minute interval.
**Wind direction: Numerals indicate tens of degrees clockwise from true north.
NOTE: The period of record for the average windspeed is 20 years, for prevailing wind direction is 9 years, and for maximum windspeed is 19 years.

D. Air Quality.

The Tennessee Air Quality Act authorized the establishment of the Division of Air Pollution Control under the Tennessee State Health Department as the regulatory agency for air quality standards. Through subsequent legislation the State was divided into four regions, excluding Davidson, Knox, Hamilton, and Shelby counties which are under separate authorities. Kingsport is included in Region I, i.e., the Eastern Tennessee-Southwestern Virginia Air Quality Control Region.

The Tennessee Air Pollution Control Board has two fixed sampling locations and one mobile monitoring station in the Kingsport vicinity. Fixed stations are located in northeast Kingsport, behind the Sullivan County Health Center (residential area) and at the Kingsport sewage treatment plant (an industrial site). Total suspended particulates ($\mu g/m^3$) have been measured at both fixed sites since 1969 (table 4), but sulfur dioxide, nitrogen oxides, ozone, and hydrocarbons have not been reported. Particulate concentrations have decreased during the sampling period, but there are still violations of both primary and secondary standards for the 24-hour mean concentrations at both sites. The irregular topography and the prevailing summer and winter calms contribute to seasonal periods of air stagnation and temperature inversions.[5]

Table 4. Annual Geometric Means for Suspended Particulates at Kingsport, Tennessee

Location	Suspended particulates annual geometric means						
	1969	1970	1971	1972	1973	1974	1975
				$\mu g/m^3$			
Residential	83.5	89.8	94.4	77.1	77.3	72.2	67.7
Industrial	207.5	174.3	152.3	136.5	153.4	151.7	120.3

Metals are common atmospheric emissions from refuse- and coal-burning operations. Extensive monitoring was conducted at both fixed sites in Kingsport using a high-volume sampler and atomic absorption analysis. The concentration of 15 metals was measured between 1 July 1973 and 30 June 1974.[6] Aluminum, copper, iron, lead, magnesium, manganese, and tin were all detected during this period. Aluminum, lead, and iron were each found in concentrations of 1.0 $\mu g/m^3$ or greater during the survey.[6]

The State also cited high soiling indices, but sulfur dioxide concentrations were not measured in excess of the primary standard. (Soiling index is a measure of particulate matter in the atmosphere. It is determined by measuring the rate at which clean filter medium is soiled during filtration.) The applicable Tennessee ambient air quality standards are summarized in table 5. Insufficient data are available from State monitoring programs to determine compliance except for suspended particulates.

The Tennessee State Health Department could not provide a source inventory from the Kingsport area, but the following companies have received permits: Tennessee Eastman Company, Kingsport Press, Mallory Battery Company, Super Dollar Market, and Northside

Table 5. Tennessee Ambient Air Quality Standards for Suspended Particulates, Sulfur Dioxide, Carbon Monoxide, Photochemical Oxidants, Nonmethane Hydrocarbons, and Nitrogen Dioxide

Contaminants	Primary standard			Secondary standard		
	Concentration		Average interval	Concentration		Average interval
	$\mu g/m^3$	ppm by vol		$\mu g/m^3$	ppm by vol	
Suspended particulates	75	-	AGM	60	-	AGM
	260	-	24 hr	150	-	24 hr
Suflur dioxide	80	0.03	AAM	1,300	0.5	3 hr
	365	0.14	24 hr			
Carbon monoxide	10,000	9.0	8 hr	10,000	9.0	8 hr
	40,000	35.0	1 hr	40,000	35.0	1 hr
Photochemical oxidant	160	0.08	1 hr	160	0.08	1 hr
Hydrocarbons (nonmethane)	160	0.24	3 hr a. m.	160	0.24	3 hr a. m.
Nitrogen dioxide	100	0.05	AAM	100	0.05	AAM

NOTE:
1. All values other than annual values are maximum concentrations not to be exceeded more than once per year.
2. Parts per million values are approximate only.
3. All concentrations relate to air at standard conditions of 25°C temperature and 760 millimeters of mercury pressure.
4. AGM - Annual geometric mean.
5. AAM - Annual arithmetic mean.
6. The hydrocarbons standard is for use as a guide to achieve oxidant standards.

Hospital. These facilities contribute hydrocarbons from the manufacturing and disposal of contaminated waste; sulfur dioxide from coal burning for power, heat, and steam; and nitrogen oxides from acid and solvent manufacturing. The State would not release data specific to industrial stack emissions, and no comparison of air quality was made between Kingsport and the surrounding areas in any of the State annual reports.

Air pollution is a problem in the Kingsport area, because there are numerous sources and meteorological and topographic conditions which tend to concentrate the stack emissions.

E. Water Quality.

The South Fork of the Holston River, from its mouth to mile 5.7, and the Holston River, from mile 131.5 to the confluence of the north and south forks, are severely polluted by multiple waste discharges from the Kingsport area. The Division of Water Quality Control, Tennessee Department of Health, considers this area to be the primary water pollution problem area in the state.[7] The Tennessee Eastman Company, Holston Army Ammunition Plant, Mead Paper Corporation, and the municipal wastewater treatment plant of the city of Kingsport are the major sources of pollutants among the fourteen dischargers with permits.

The water quality problem is intensified by fluctuating streamflow and low concentrations of dissolved oxygen in water entering the Kingsport area through releases from the TVA Fort Patrick Henry Dam and hydroelectric facility located on the South Fork of the Holston River at mile 8.2. During the summer, water released from this facility is low in dissolved oxygen (frequently below 1.0 mg/l). These low concentrations of dissolved oxygen greatly reduce the capacity of the river to assimilate the large load of organic wastes discharged in the Kingsport area. The problem originates at Boone Dam, where low dissolved oxygen occurs in summer when the lake is stratified. This poor-quality water is released unchanged into Fort Patrick Henry Reservoir.

Table 6 presents a list of major discharges and their characteristics in the Kingsport vicinity. The Tennessee Eastman Company contributes two-thirds of the total organic waste loading from all sources in the area. The description of waste treatment and discharges was obtained from State records which were updated in October 1975.[7]

The past operations of the Olin Mathieson Corporation, Saltville, Virginia, have seriously polluted the North Fork of the Holston River with dissolved solids, chloride, and mercury.[2] The problem of dissolved solids, which frequently resulted in high calcium hardness in the Holston River as far downstream as Knoxville, Tennessee, has diminished greatly since the Olin Mathieson Corporation abandoned its plant in 1971. However, mercury is still present in the sediments, and concentrations in fish are nearly twice those allowed by the Food and Drug Administration for human consumption. Leaching from the abandoned slurry ponds and runoff from contaminated facilities of the Olin Mathieson Corporation may still be contributing to the problem.

In a 1972 survey of the Holston River Basin, EPA found that approximately 137,500 pounds per day of biochemical oxygen demand (BOD) were discharged into the Holston River and the south fork in the vicinity of Kingsport, Tennessee.[2] The ultimate oxygen demand from nitrification of these nitrogenous components was 84,000 pounds. Extensive sludge beds, estimated as covering 25% of the bottom, were found[2] between the confluence of the north and south forks and the headwaters of Cherokee Reservoir in the Holston River. Most of the increases in temperature, total nitrogen, and BOD were contributed by the Tennessee Eastman Company and Holston Army Ammunition Plant, A and B areas. The EPA states that these pollutants must be removed to improve the quality of the water.

III. INSTALLATION INFORMATION.

A. Description.

Holston Army Ammunition Plant is divided into two separate areas: "A", which is located within the city of Kingsport in Sullivan County, Tennessee, on State Route 93; and "B" in Hawkins County, 5 miles west of downtown Kingsport on US Route 11-W.

Area A in down Kingsport is the smaller of the two locations, comprising 112 areas. Area B, the principal subject of this report, covers 5,913 acres which are bounded on the north and west by open rolling country and on the east and south by the Holston River. Beyond the river lies Bays Mountain, whose ridge forms the southern perimeter of the installation.

Of the total acreage, 33 acres are improved; 1,086 acres are semi-improved; 1,111 acres are unimproved; and 3,828 acres are forested.

Table 6. Industrial Waste Sources on the Holston River in the Vicinity of Kingsport, Tennessee

River mile	Receiving stream	Industry	Principal product; number of employees	Waste type	Volume*	Type treatment	Treated waste** characteristics
					Mgal/d		
125.4	Holston River	American Saint Gobain Glass Works Plant; Hunts Gap Sand and Clay Corporation	Plate glass - 702	Sanitary	0.02	Aeration, sedimentation	BOD, 45 mg/l; suspended solids, 35 mg/l
				Sand and quarry	0.01	Settling	Suspended solids
				Glass process	4.5	Coagulation, settling lagoon	pH 6-7, suspended solids, 784 mg/l; settleable solids, 0.3 mg/l; iron, 16.2 mg/l; lead, 0.2 μg/l; zinc, 0.6 mg/l
129.1	Holston River	Holliston Mills, Inc.	Book binding material - 500	Process	0.715	Screening, neutralization, clarification, sludge disposal, trickling filter	pH 7.4; BOD, 442 mg/l; suspended solids, 165 mg/l; settleable solids, 0.3 mg/l; NH_3-N, 2 mg/l; COD, 1,160 mg/l
				Boiler blowdown	0.292	None	pH 7.5; BOD, 18 mg/l
141.6	Holston River	Holston Army Ammunition Plant, area B	Nitric acid, ammonia nitrate, explosives	Filter plant backwash No. 001	1.0	None	BOD, 36 mg/l; NH_3-N, 1 mg/l; NO_3, 1 mg/l; suspended solids, 1.653 mg/l
140.2	Holston River	Holston Army Ammunition Plant, area B	Nitric acid, ammonia nitrate, explosives	Sanitary No. 002	0.14	Sedimentation, trickling filter, chlorination	BOD, 5 mg/l; suspended solids, 4 mg/l
140.3	Holston River	Holston Army Ammunition Plant, area B	Nitric acid, ammonia nitrate, explosives	Surface drainage No. 003	-	None	–
139.7	Holston River	Holston Army Ammunition Plant, area B	Nitric acid, ammonia nitrate, explosives	Process No. 004	1.2	None	BOD, 70 mg/l; suspended solids, 18 mg/l; NH_3-N, 4 mg/l; NO_3, 10 mg/l
139.6	Holston River	Holston Army Ammunition Plant, area B	Nitric acid, ammonia nitrate, explosives	Process, cooling, surface runoff No. 005	38.0	None	BOD, 21 mg/l; suspended solids, 51 mg/l; NH_3-N, 3 mg/l; NO_3, 1 mg/l
139.2	Holston River	Holston Army Ammunition Plant, area B	Nitric acid, ammonia nitrate, explosives	Process No. 007	2.4	None	BOD, 166 mg/l; suspended solids, 25 mg/l; NH_3-N, 3 mg/l; NO_3, 1 mg/l
137.9	Holston River	Holston Army Ammunition Plant, area B	Nitric acid, ammonia nitrate, explosives	Process and surface drainage No. 008	54.71	None	BOD, 13 mg/l; suspended solids, 25 mg/l; NH_3-N, 3 mg/l; NO_3, 2 mg/l
129.1	Holston River	Kingsport Press, Plant No. 2	Book printing and book binding - 500	Process and sanitary	0.03	Extended aeration	BOD, 224 mg/l; suspended solids, 140 mg/l; NH_3-N, 15 mg/l; chromium, 1.7 mg/l; iron, 10 mg/l; zinc, 20 mg/l; settleable solids, 0.9 ml/l

NOTE: See end of table for footnotes.

Table 6 (Contd)

River mile	Receiving stream	Industry	Principal product; number of employees	Waste type	Volume*	Type treatment	Treated waste** characteristics
					Mgal/d		
106.2	Holston River	TVA-John Sevier Steam Plant	Electric power generation - 225	Process and sanitary	4.0	Sedimentation	pH 7.7; alkalinity, 70 mg/l; sulfates, 98 mg/l; manganese, 0.19 mg/l
				Cooling	586.0	None	Temperature rise, 15°F
4.0	South Fork of Holston River	American Saint Gobain Glass Works Plant	Pattern glass, polished wire glass - 1,513	Process and cooling No. 001	0.37	None	Suspended solids, 140 mg/l; BOD, 4 mg/l
				Process and surface runoff No. 002	0.57	Limestone neutralization	BOD, 2 mg/l; suspended solids, 1,760 mg/l; settleable solids, 6 ml/l
2.5	South Fork of Holston River	Air Products and Chemicals, Inc., Southern Oxygen Division	Acetylene gas - 32	Process	0.0008	Settling and recycle	No discharge
3.0	South Fork of Holston River	General Shale Products	Concrete and cinder building blocks and building and facing brick - 214	Plant No. 8 process	0.02	None	Suspended solids, 52 mg/l; chromium, 0.120 mg/l
				Plant No. 1 and No. 15, process No. 001	0.006	None	Suspended solids, 48 mg/l
				Plant No. 1 and No. 15, process No. 002	0.004	None	Suspended solids, 12 mg/l; chromium, 0.090 mg/l
4.0	South Fork of Holston River	Holston Army Ammunition Plant, area A	Industrial organic chemicals - 100	Process and cooling	43.3	Aerated lagoon	BOD, 12 mg/l; pH 7.4; dissolved solids, 116 mg/l
0.5	Reedy Creek	Kingsport Press, Plant No. 1	Book printing and book binding - 2,200	Process and cooling	0.094	None	pH 11, zinc, 12.5 mg/l
0.9	Reedy Creek	Lynn Garden Wishy-Washy	Coin laundry	Laundry	0.0078	Screening, trickling filter, chlorination	BOD, 125 mg/l; suspended solids, 98 mg/l; settleable solids, 0.4 ml/l
0.3	Leslie Creek	Mason and Dixon Lines, Inc.	Truck maintenance servicing and washing - 667	Process	0.012	Sand filter	Oil and grease, 19 mg/l; NH_3-N, 1.2 mg/l; BOD, 56 mg/l
		Mason and Dixon Lines, Inc.		Sanitary	0.029	Aeration, settling, sand filter	BOD, 16 mg/l; suspended solids, 1 mg/l
2.3	South Fork of Holston River	Mead Papers, Kingsport Mill	Pulp and paper - 1,020	Process	18.8	Primary settling, aerated lagoon	BOD, 24 mg/l; suspended solids, 127 mg/l; settleable solids, 0.1 ml/l; pH 7.3; phosphorus as P, 47 mg/l

Table 6 (Contd)

River mile	Receiving stream	Industry	Principal product; number of employees	Waste type	Volume*	Type treatment	Treated waste** characteristics
					Mgal/d		
2.5	South Fork of Holston River	Penn-Dixie Cement Corporation	Portland cement - 131	Process	0.025	Precipitation, clarification, and neutralization	Dissolved solids, 1700 mg/l; settleable solids, 10 mg/l; sulfates, 5200 mg/l; pH 7.6
				Cooling	0.038	None	Temperature rise
5.0	South Fork of Holston River	Pet, Inc., Dairy Division	Processed milk - 117	Cooling and wash	0.022	None	BOD, 180 mg/l; COD, 155 mg/l
0.7	Horse Creek	Slip-Not Belting Company	Leather and nylon belting, and leather strap - 91	Process	0.0030	Neutralization, filtration, aeration, sedimentation, chlorination	BOD, 34 mg/l; pH 8.6; suspended solids, 30 mg/l; settleable solids, 0.1 mg/l; chromium, 0.2 mg/l; phenols, 0.032 mg/l; oil and grease, 123 mg/l
4.4	South Fork of Holston River	Tennessee Eastman Company	Synthetic fibers, plastics, and chemicals - 11,575	Cooling, process, and water treatment plant No. 001	327	Neutralization	pH 6.1-7.7; BOD, 8,400 lb/d; NH_3–N, 700 lb/d; total Kjeldahl nitrogen (organic nitrogen), 2,600 lb/d
3.5	South Fork of Holston River	Tennessee Eastman Company	Synthetic fibers, plastics, and chemicals - 11,575	Process No. 002	11	Aerated lagoon	BOD, 49,400 lb/d; suspended solids, 67,900 lb/d; NH_3-N, 3,800 lb/d; total Kjeldahl nitrogen, 12,300 lb/d; phosphorus, 1,890 lb/d
3.9	South Fork of Holston River	Tennessee Eastman Company	Synthetic fibers, plastics, and chemicals - 11,575	Surface drainage and process No. 003	0.136	None	BOD, 327 lb/d; suspended solids, 210 lb/d
5.5	South Fork of Holston River	Tennessee Eastman Company	Synthetic fibers, plastics, and chemicals - 11,575	Cooling, surface drainage, and process No. 004	7.16	None	BOD, 537 lb/d; suspended solids, 700 lb/d
5.2	South Fork of Holston River	Tennessee Eastman Company	Synthetic fibers, plastics, and chemicals - 11,575	Cooling, surface drainage, and process No. 005	4.52	None	BOD, 783 lb/d; suspended solids, 19,700 lb/d
5.4	South Fork of Holston River	Tennessee Eastman Company	Synthetic fibers, plastics, and chemicals - 11,575	Cooling, surface drainage, and process No. 006	9.37	None	BOD, 1,300 lb/d; suspended solids, 600 lb/d
5.8	South Fork of Holston River	Tennessee Eastman Company	Synthetic fibers, plastics, and chemicals - 11,575	Ash pit runoff No. 008	0.2	Settling	pH 4-10; temperature 87°F; suspended solids, 334 lb/d

NOTE: Abbreviations used under treated waste characteristics column are as follows: NH_3-N – ammonia nitrogen, NO_3 – nitrate nitrogen, COD – chemical oxygen demand, BOD – biochemical oxygen demand.

*Average daily use may not be indicative of waste discharged as given in this table due to recirculation and evaporation losses or recycling of waste water.

**Parameters listed are considered likely to be found in significant quantity in the discharged waste; where concentrations of the specific parameter are not given, no data were available in the Division of Water Quality Control, Tennessee State Health Department, Nashville, Tennessee.

The distance and direction of the nearest cities in relation to area B are tabulated below:

County	City	Population	Distance mi	Direction
Sullivan	Kingsport	33,100	0.5	NE
	Bristol	23,800	25.0	ENE
Washington	Johnson City	33,770	25.0	SSE

Table 1 contains further geographical information.

B. History and Mission.

The explosive RDX, developed by the British in the interval between World War I and World War II, was recognized by the United States at the time of our entry into World War II as an essential explosive for our success in that conflict. The Tennessee Eastman Company in Kingsport had been engaged in the laboratory and pilot plant development of the RDX process since January 1941, and this endeavor was expanded. In May 1942, a series of conferences between the United States Army, the Corps of Engineers and the Tennessee Eastman Company culminated in a contract for the construction of the Holston Ordnance Works.[8]

Holston's operation was unusual in that a pilot plant was expanded into a very large production plant during wartime with attendant material shortages and manpower scarcity. Construction began on 1 July 1942 and was completed on 15 March 1944, but the first production line went into operation early in May 1943. Seven more production lines were ready in the following two months. The finished plant in area B consisted of 10 identical lines operating under a continuous batch process, with raw materials being fed into the beginning of each line and the finished product being boxed and shipped from the end. The completed plant became one of the largest high-explosives manufacturing plants in the world, daily producing, during peak production, 750 tons of composition B. The total output during its operating life was 434,000 tons. This powerful explosive was used in bombs, shells, and demolition devices. Peak employment during World War II was 6,854 contractor employees and 500 Government employees. The plant was operated as Holston Ordnance Works-Tennessee Eastman Company from 6 June 1942 to 1 May 1946, when it went into a standby status until 1 April 1949. From that date until the present, the Holston Defense Corporation (HDC), a subsidiary of Eastman Kodak Company, has operated portions of HAAP under contract. Although HAAP was originally designed for high-volume production of composition B, changing techniques of warfare have resulted in requirements for special types of weapons, missiles, and rockets incorporating such products as Cyclotol, compositions A-3 and B-3, and M5A1 demolition blocks. In FY66, there were 70 different explosives produced. Materials are shipped to the Army, Air Force, Navy, atomic energy agencies, and NASA contractors.[8]

The main mission of HAAP is the production of RDX, composition B, HMX, HMX-TNT*, RDX-plasticizer, and other specifically ordered, explosive compounds.[8-10] Manufacturing operations are conducted in two separate areas. Area A operations consist of the refining and concentration of acetic acid, the manufacture of acetic anhydride, and the storage of raw and unrefined organic acids. Area B operations consist of the production of concentrated nitric acid and the nitration of hexamine to manufacture explosives, the blending of explosive compounds, and the recovery of acetic acid.

*TNT – trinitrotoluene.

As a class II, Government-owned, contractor-operated ammunition plant, HAAP handles and stores explosives. The Government staff assures that the provisions of the contract are fulfilled by Holston Defense Corporation (HDC) and coordinates administrative needs of higher headquarters with HDC.

C. Topography and Drainage.

The Holston A plant area is on relatively flat terrain on the Holston River terrace, about 1,200 feet above sea level. Regulation of the river discharge from the Fort Patrick Henry Dam by the TVA has eliminated flooding problems which previously occurred over one-third of the B plant area to a maximum elevation of 1,185 feet. TVA established the maximum height of flooding as 1,176 feet since the south fork was regulated. Waters of this second level would inundate the floodplains containing HAAP's burning ground and sewage treatment plant during a flow exceeding 100,000 ft^3/s (predicted every 200 years[2]).

In the A area complex, the manufacturing area drains south to Holston River and northwest to Mad Branch (also called Unnamed Creek). In the B plant, the manufacturing area drains into the combined forks of the Holston River through six drainage ditches with a total length of 14 miles (figure 2). Drainage ditches carry surface water from the burning grounds, potential overflow from the sodium nitrate lagoons, and process and cooling waters from the explosive manufacturing area. The acid area and the primary distillation, steam plant, and ammonia recovery areas are all drained by Arnott Branch. The primary manufacturing area is gently rolling, whereas the administration area is somewhat hilly, rising above 1,300 feet in elevation in the western portion. The two areas are separated by a ridge so that the manufacturing area is not visible from US Highway 11-W. The raw water reservoir is located on this ridge near the highest point in the area north of the river. The magazine storage area grades from gently rolling land in the western portion to very steep areas which exceed 2,200 feet at the eastern border. The major, named drainages from the storage area are Sand Branch and Parker Creek, but each intervening valley of the Holston River Mountain is considered so rugged that timber harvest management areas are largely restricted to the foothills. Marshland occurs on the floodplains between the river and the magazine area.

D. Air Quality.

The ambient air quality monitoring program at HAAP consists of high-volume air sampling for suspended particles taken weekly for a 24-hour period. Monitoring is conducted at four sites (shown in figure 3; letter G in area A and letters A, B, and E in area B). The results from 1975 are summarized in table 7.

All data are submitted to the Tennessee State Air Pollution Control Board, Nashville, Tennessee, and violations are reported in writing. The State is satisfied with HAAP plans for pollution abatement. However, they have urged HAAP to proceed to compliance more rapidly. The large number of suspended particulate violations at area A are probably a combination of the emissions from many adjacent coal-burning and chemical-manufacturing sources. During our visit, we observed visible emissions from the nitric acid concentrator and the central coal-fired heating plant in area B. Vegetation in the downwind areas was examined for potential damage. Although pine trees in this area had yellowing of the needles and some other symptoms of nitrogen oxide damage, the cause of these symptoms could not be traced to HAAP without further study of their emissions. During periods of temperature inversion, photochemical smog, another pollutant causing plant damage, is common throughout the Kingsport area.

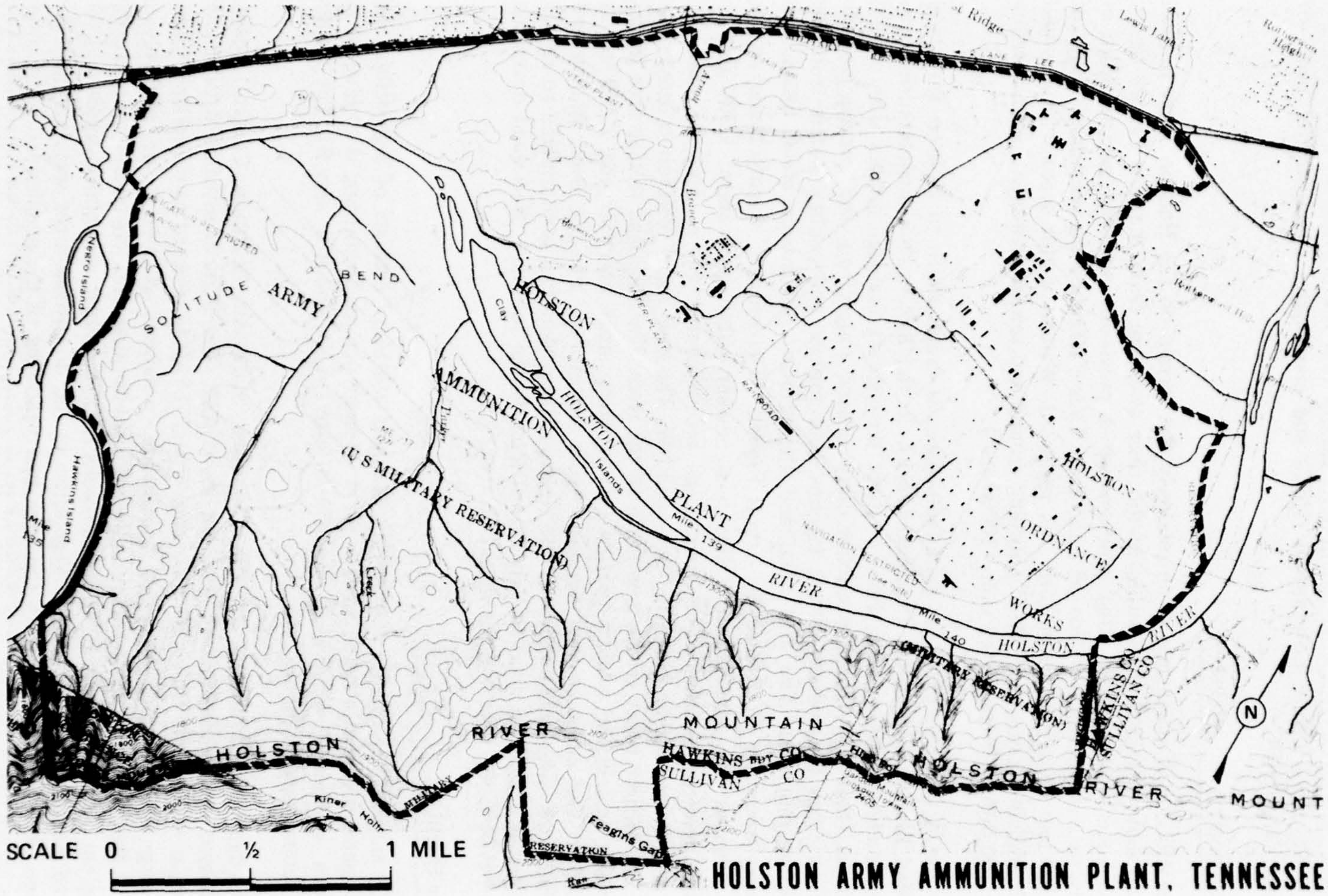
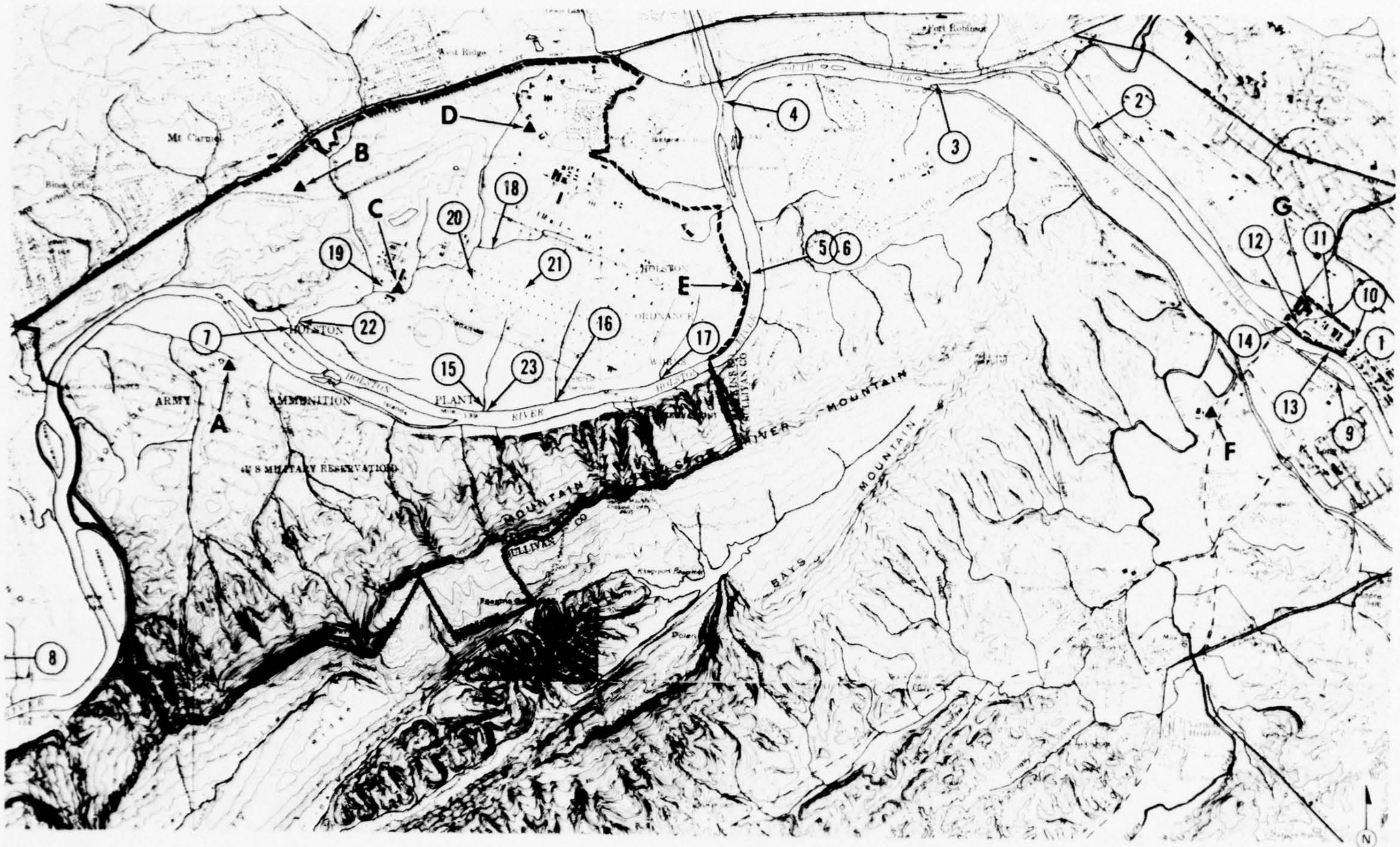


Figure 2. Topography and Drainage from Holston Army Ammunition Plant, Area B

Detailed drainage and topography from area A are not shown because the drainage is man-made and there is little relief. The installation boundary is based on a 1971 US Geological Survey topographic map. A small portion of the northeast corner of the installation has since been sold.



HOLSTON ARMY AMMUNITION PLANT, TENNESSEE

AIR AND WATER QUALITY MONITORING STATIONS

SCALE 0 ½ 1 MILE

Figure 3. Locations of Ambient Air and Water Quality Monitoring Stations

There are seven sites proposed for the HAAP air monitoring program (letters), but only six air monitoring sites will be equipped with a trailer. The seventh site will be used as needed, depending on the production lines that are operating. The numbers of some water quality stations are identified in table 8.

Table 7. Suspended Particulate Data* Summary ($\mu g/m^3$) for Holston Army Ammunition Plant September 1975-February 1976

Station	Area A (G)**	Burning ground (E)	Filtered water reservoir (C)	Hospital (D)
Number of samples	19	19	19	19
First 24-hour maximum	186.3	90.4	130.4	125.6
Second 24-hour maximum	186.2	79.4	125.4	125.6
Times exceeded 24-hour primary standard	0	0	0	0
Times exceeded 24-hour secondary standard	4	0	0	0
Annual geometric mean	125.9	58.6	91.4	70.7
Standard deviation	38.6	16.1	19.1	24.7

*Test was based on a 24-hour continuous sampling period and was conducted in accordance with the listed method in Fed. Regis. 36 (84), 1086-1095 (April 1971).

**Corresponding map symbol.

In 1971, the US Army Environmental Hygiene Agency (USAEHA) conducted source and ambient air monitoring.[10] The stations shown in figure 3 sampled SO_2, NO_2, acid mist (as sulfuric acid), suspended particulates, windspeed, and wind direction. During higher levels of production, USAEHA found that, in area A, the steam plant contributed about 12% to the ambient SO_2 concentrations and the azeotropic stills contributed about 14% to the ambient NO_2 concentration. They identified the Holston River Valley adjacent to Bays Mountain as a natural sink for the accumulation of pollutants and suggested that SO_2 and NO_2 monitoring be established. USAEHA also recommended that the physiological responses of plant employees be monitored if high pollution levels were found in area B near the bridge to the magazine area.

In general, air quality within both areas was found to be in compliance with existing State standards and Federal guidelines (including Army Regulation 11-21) as of 1972. Suspended particulates, oxidants, and acid mist were all in violation during some period of measurement.

The agency recommended that HAAP establish ambient monitoring stations for SO_2 and NO_2.[10] The design and procurement of these units was assigned to the Corps of Engineers Mobile District under LI-24 MCA project, and six trailers equipped with monitoring equipment for NO_2, NO_3, SO_2, and suspended particulates are scheduled for delivery in 1977. Contracts for trailer construction were awarded to Xonics, Inc., Van Nuys, California. Actually, seven sites have been prepared by the Corps of Engineers. Instrumentation for monitoring total hydrocarbons (as methane), coefficient of haze, acid mist, windspeed, and wind direction at two or three sites is being procured, but the specific locations have not yet been selected. These stations will be operated by trained personnel from HDC. Originally, each trailer was planned to be equipped with an alarm for SO_2 and NO_2, but this system appears to be too costly.

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E. Water Quality.

The water quality of the Holston River in the vicinity of HAAP is considered poor[2,11] as shown by data in the area water quality section. The characteristics of wastewater from HAAP (both areas A and B) are presented in the manufacturing emissions section.

A program to monitor water quality is conducted by HDC, HAAP, and is designed to meet two objectives: (1) to furnish background data on the characteristics and quality of raw water sources at HAAP and (2) to facilitate process control through the early detection of leaks or spills.[12] Nine points in area A and eleven points in area B are sampled weekly with composite sampling (figure 3). These monitoring points include stations in the receiving waters above and below each area (table 8).

Malfunctions are detected principally through continuous pH monitoring at major effluent outfalls to the Holston River in both areas. Grab samples are analyzed for BOD, chemical oxygen demand (COD), pH, organic carbon, inorganic carbon, settleable solids, dissolved solids, suspended solids, hardness, phosphates, chlorides, and water temperatures. Measurements of the explosives components (RDX, HMX, and TNT), organic solvents (acetone, toluene, and cyclohexanone), total nitrogen, ammonia nitrogen, organic nitrogen (Kjeldahl nitrogen), hardness (total, calcium, and magnesium), and turbidity are measured in industrial wastewater streams on area B.

The descriptions of the monitoring stations (table 8) show that they were selected to achieve the multiple objectives stated above. The sampling locations, the rationale for their selection, and the methods for analysis were detailed in a report by USAEHA.[13] The parameters and the methods recommended were based on the legal requirements of the Office of the Pollution Control Board, Tennessee Department of Public Health, Nashville, which were promulgated on 17 May 1971 for HAAP. The actual sampling locations are shown in figure 3, excluding the industrial outfalls within area A. HAAP received a new permit on 28 July 1974 (table 9), which also had seasonal discharge limitations for nitrogen forms and BOD which become effective 1 July 1977. The new monitoring requirements also include quarterly measurements of phenols, copper, mercury, chromium, lead, and settleable solids.

Holston Defense Corporation water quality monitoring data from CY75 are summarized and presented in tabular form for all monitoring stations (tables 10 and 11). The first group (stations A01_ and B01_) are water quality stations (table 10). No measurements were reported for stations A01A through A01E in table 10 for explosives (RDX/HMX and TNT), turbidity, solvents (acetone and cyclohexanone), nitrogen (total nitrate, ammonia, and organic), and suspended solids. Explosives, solvents, and suspended solids were not reported for stations B01A through B01C. The data reported in table 11 are from stations that are used to monitor industrial and cooling waters. Explosives, turbidity, solvents, nitrogen, and suspended solids were not reported from stations A02A through A02E. Data from this table are further discussed in the section titled "Manufacturing Emission." A single determination of COD (743 mg/l) was made at station A02Q, an outfall from building 20. From reviewing the data provided, there are no measurements reported of solvents, explosives, or nitrogen, which are characteristic of HAAP wastewaters before settling, from stations in the Holston River. In this respect, the reporting of the data is inadequate. The water carried in the many underground effluent pipes discharging directly into the river probably has a very low concentration of dissolved oxygen (DO). Water and Air Research found DO concentrations at one such outfall which supports this.[13] There are no data from HAAP monitoring on DO from underground effluents, although the continuous

Table 8. Sampling Stations for Holston Defense Corporation
Water Quality Monitoring Program

Map identification number	HAAP identification number	Description
1	A01A	Upstream of area A in the South Fork of Holston River.
2	A01B	Downstream of area A, above Mead Paper Company outfalls.
3	A01C	Downstream of Reedy Creek, above the convergence of the sluice (Ridgefield Bridge).
4	A01D	North Fork of the Holston River above the convergence with the South Fork.
5	A01E	Holston River upstream of area B.
6	B01A	Holston River, area B water intake.
7	B01B	Holston River, Igloo Bridge (Arnott Branch).
8	B01C	Holston River, Church Bridge, downstream of HAAP, area B.
9	A02A	Holston River, water intake for area A.
10	A02B	Waste stream entering area A from American Saint Gobain glass plant.
11	A02C	Surface runoff from Kingsport entering area A.
N.S.*	A02D	Industrial wastes from building 2 (acetic acid concentration), area A.**
N.S.	A02E	Cooling waters from building 2, area A.**
12	A020	Main effluent from area A (west side).
13	A02P	Underground effluent from area A (east side).
N.S.	A02Q	Outfall from building 20 (anhydride making), area A.
14	A02R	Waste treatment lagoon effluent.
15	B02A	Underground effluent from lines 1-5, area B.
16	B02B	Underground effluent from lines 6-7, area B.
17	B02C	Underground effluent from lines 8-10, area B.
18	B02D	Manhole 148, effluents from shop area and the washing, primary recovery, nitration, and hexamine solution buildings of lines 1-5.
19	B02E	Manhole, effluents from acid area.
20	B02F	Manhole 215, effluents from purification, filter, and weighing processes, lines 1-2 (no data).
21	B02G	Manhole 308, effluents from nitration, washing, and purification processes in lines 6-7.
22	B03B	Arnott Branch, near Holston River.
23	B03C	Surface drainage from lines 1-5.

*N.S. - not shown on map.
**These effluents enter the main area A discharge to the river.

Table 9. Effluent Limitations and Monitoring Requirements for Holston Army Ammunition Plant

During the period beginning 1 July 1977 and lasting through 28 July 1979, the permittee is authorized to discharge treated process and domestic wastewater, including wastewaters transported from area A and treated at area B. Such discharges shall be limited and monitored by the permittee as specified below:

Effluent characteristic	Discharge limitations				Monitoring requirements[a]	
	Kilograms per day (pounds per day)		Other units (specify)		Measurement frequency	Sample type
	Daily average[b]	Daily maximum[b]	Daily average[c]	Daily maximum[c]		
Flow, m^3/d	NA	NA	NA	NA	Continuous	NA
BOD_5 (1 May-31 October)	367 (810)	735 (1620)	NA	NA	Daily, 24 hours	Composite
BOD_5 (1 November-30 April)	551 (1215)	1100 (2430)	NA	NA	Daily, 24 hours	Composite
Total suspended solids	227 (500)	454 (1000)	NA	NA	Daily, 24 hours	Composite
Total dissolved solids	<272,000 (<600,000)	272,000 (600,000)	NA	NA	Quarterly	Grab
Total nitrogen (1 May-31 October)	175 (385)	354 (780)	NA	NA	Daily, 24 hours	Composite
Total nitrogen (1 November-30 April)	272 (600)	354 (780)	NA	NA	Daily, 24 hours	Composite
Ammonia (as nitrogen) (1 May-31 October)	45 (100)	91 (200)	NA	NA	Daily, 24 hours	Composite
Ammonia (as nitrogen) (1 November-30 April)	91 (200)	136 (300)	NA	NA	Daily, 24 hours	Composite
Phosphorus, total	<97 (<213)	97 (213)	NA	NA	Daily, 24 hours	Composite
Phenols	4.5 (10)	9 (20)	NA	NA	Daily, 24 hours	Composite
Chromium, total	NA	NA	0.05 mg/l	0.05 mg/l	Quarterly	Grab
Copper, total	NA	NA	0.05 mg/l	0.10 mg/l	Quarterly	Grab
Lead, total	NA	NA	0.05 mg/l	0.05 mg/l	Quarterly	Grab
Mercury, total	NA	NA	0.005 mg/l	0.005 mg/l	Quarterly	Grab
Settleable solids	NA	NA	0.5 ml/l	0.5 ml/l	Quarterly	Grab

[a] Monitoring requirements effective 1 July 1977.
[b] Discharge limitations effective 1 July 1977.
[c] Current discharge limitations effective through 30 June 1977.

Table 10. Stream Quality Data Summary from Holston Defense Corporation Water Quality Monitoring Program, 1975*

	BOD	COD	Total carbon	Inorganic carbon	Organic carbon	pH	Nitrates	Turbidity	Total nitrate	Ammonia nitrogen	Organic nitrogen	Dissolved solids	Total hardness	Calcium hardness	Magnesium hardness	Total phosphate	Chloride	Settleable solids	Water temperature
																		ml/l	°C
Station A01A																			
Mean	2	15	26	17	8	7.2	5.2	0	0	0	0	114	35	30	4	0.1	5	0.2	16
Standard deviation	1.4	17.2	4.3	2.4	4.2	0.24	1.59	0	0	0	0	0	1.7	2.8	2.4	0.09	1.3	0.17	5.3
Maximum	7	47	37	22	23	7.7	9.5	0	0	0	0	0	37	35	8	0.3	10	0.5	23
Minimum	1	4	19	10	2	6.7	2.5	0	0	0	0		33	26	2	0	3	0	6
Number observed	31	7	29	29	29	31	29	0	0	0	0	1	7	7	7	28	28	6	25
Station A01B																			
Mean	2	13	27	17	9	7.2	5.2	0	0	0	0	127	36	33	3	0.1	5	0.1	16
Standard deviation	1.2	7.1	4.3	3.0	4.7	0.19	1.79	0	0	0	- 0	29.6	3.6	3.9	1.1	0.00	0.6	0.09	5.1
Maximum	5	25	34	26	23	7.6	11.5	0	0	0	0	148	44	41	5	0.3	7	0.2	22
Minimum	0	4	20	11	1	6.9	2.3	0	0	0	0	106	32	28	1	0.0	5	0.0	8
Number observed	32	8	30	30	30	32	30	0	0	0	0	2	8	8	8	29	10	7	25
Station A01C																			
Mean	2	18	27	18	8	7.3	4.7	0	0	0	0	137	38	35	3	0.1	0	0.0	9
Standard deviation	1.1	21.8	5.1	4.3	7.1	0.24	0.81	0	0	0	0	1.4	5.6	5.3	2.0	0.00	0	0.00	1.4
Maximum	4	70	38	25	25	7.6	6.2	0	0	0	0	138	51	48	8	0.2	0	0.1	11
Minimum	1	2	20	13	3	6.9	3.5	0	0	0	0	136	32	30	2	0.0	0	0.0	8
Number observed	8	8	8	8	8	8	8	0	0	0	0	2	8	8	8	8	0	7	5
Station A01D																			
Mean	1	17	30	20	10	7.5	7.1	0	0	0	0	146	40	38	2	0.1	32	0.1	17
Standard deviation	0.8	13.6	7.0	5.0	4.7	0.28	2.92	0	0	0	0	28.2	8.1	8.0	0.7	0.09	49.6	0.14	5.6
Maximum	3	40	47	28	25	8.0	16.0	0	0	0	0	166	55	52	3	0.4	183	0.3	22
Minimum	1	2	17	12	2	7.0	4.3	0	0	0	0	126	32	30	1	0.0	5	0.0	4
Number observed	29	8	26	26	26	29	26	0	0	0	0	2	8	8	8	26	25	7	21
Station A01E																			
Mean	3	28	27	17	9	7.3	4.9	0	0	0	0	138	39	36	3	0.2	5	0.1	8
Standard deviation	0.7	41.3	5.8	4.1	7.0	0.24	1.13	0	0	0	0	8.4	4.9	4.7	1.0	0.09	0.9	0.09	2.1
Maximum	4	128	39	25	26	7.7	6.4	0	0	0	0	144	48	45	4	0.3	7	0.3	11
Minimum	2	2	18	12	4	7.0	3.3	0	0	0	0	132	32	30	1	0.1	5	0.0	5
Number observed	8	8	8	8	8	8	8	0	0	0	0	2	8	8	8	8	8	7	5
Station B01A																			
Mean	2	44	27	18	8	7.4	6.4	19	0.2	0.0	0	179	41	38	3	0.1	16	0.1	18
Standard deviation	0.8	89.0	3.9	2.8	4.2	0.28	3.07	3.0	0.59	0.14	0.5	1.4	6.0	5.6	1.0	0.00	18.4	0.14	4.1
Maximum	5	280	38	26	24	8.0	16.2	23	3.0	0.7	3	180	53	48	5	0.2	77	0.4	21
Minimum	1	2	20	13	2	6.8	3.0	15	0.0	0.0	0	179	35	31	2	0.0	5	0.0	10
Number observed	31	9	29	29	29	30	30	6	29	29	29	2	7	7	7	27	25	7	20
Station B01B																			
Mean	2	15	27	18	8	7.4	6.7	16	0.3	0.0	0	178	42	39	3	0.1	17	0.1	18
Standard deviation	1.6	9.1	3.8	2.6	3.8	0.28	3.25	3.1	1.49	0.17	1.4	5.6	5.6	5.9	0.5	0.09	18.5	0.17	4.4
Maximum	9	31	37	24	23	8.0	16.2	20	8.0	0.9	8	182	53	50	4	0.4	74	0.5	21
Minimum	1	1	20	14	2	7.0	2.3	12	0.0	0.0	0	174	36	32	2	0.0	5	0.0	9
Number observed	32	10	30	30	30	31	31	7	29	29	29	2	8	8	8	28	26	8	20
Station B01C																			
Mean	3	22	31	17	13	7.4	5.3	16	0.1	0.1	0	162	42	39	3	0.1	8	0.1	10
Standard deviation	0.7	23.2	10.0	1.8	11.5	0.31	1.24	3.5	0.37	0.37	0.0	2.8	5.9	6.0	0.8	0.14	4.5	0.14	0.5
Maximum	4	78	52	20	38	8.0	8.3	21	1.0	1.0		164	54	51	4	0.4	20	0.4	10
Minimum	2	4	22	14	5	7.0	4.4	10	0.0	0.0		160	36	32	1	0.0	7	0.0	9
Number observed	9	9	8	8	8	9	8	7	7	7	7	2	8	8	8	8	8	8	3

*All measurements are in milligrams per liter except pH, settleable solids, and water temperature.

Table 11. Effluent Water Quality Data Summary from Holston Defense Corporation Water Quality Monitoring Program, 1975*

	BOD	COD	Total carbon	Inorganic carbon	Organic carbon	RDX/HMX TNT	RDX	HMX	TNT	pH	Nitrates	Turbidity	Acetone	Cyclohexanone	Total nitrate	Ammonia nitrogen	Organic nitrogen	Dissolved solids	Total hardness	Calcium hardness	Magnesium hardness	Total phosphate	Chloride	Settleable solids	Water temperature
																								ml/l	°C
Station A02A																									
Mean	2	18	26	17	8	0.0	0.0	0.0	0.0	7.3	4.9	0	0	0.0	0.0	0.0	0	132	35	31	4	0.1	4	0.3	16
Standard deviation	1.5	29.5	4.6	2.5	4.0	0.00	0.00	0.00	0.00	0.22	1.68	0.0	0.0	0.00	0.00	0.00	0.0	11.3	1.5	2.9	2.9	0.09	1.0	0.70	5.1
Maximum	6	86	40	21	16					7.6	9.4							140	37	35	9	0.4	5	1.9	23
Minimum	0	2	17	13	1					6.9	1.8							124	33	25	1	0.0	0	0.0	7
Number observed	31	8	29	29	29	0	0	0	0	31	29	0	0	0	0	0	0	2	8	8	8	28	28	7	24
Station A02B																									
Mean	5	52	33	16	16	0.0	0.0	0.0	0.0	8.8	42.6	0.0	0	0.0	0.0	0.0	0	265	43	38	5	0.9	0	4.4	17
Standard deviation	2.4	26.3	5.9	4.4	6.3	0.00	0.00	0.00	0.00	1.16	36.09	0.0	0.0	0.00	0.00	0.00	0.0	156.9	19.7	19.0	1.6	0.40	0.0	5.49	1.5
Maximum	11	90	42	24	28					10.8	99.9							376	90	82	8	1.6		15.0	19
Minimum	2	6	31	11	9					7.2	5.4							154	31	24	3	0.4		0.2	15
Number observed	8	8	8	8	8	0	0	0	0	8	8	0	0	0	0	0	0	2	8	8	8	8	0	7	5
Station A02C																									
Mean	6	20	49	33	15	0.0	0.0	0.0	0.0	7.1	7.7	0	0.0	0.0	0.0	0.0	0	306	71	66	5	0.9	0	0.0	7
Standard deviation	5.0	11.3	14.7	7.5	13.3	0.00	0.00	0.00	0.00	0.17	1.70	0.0	0.0	0.00	0.00	0.00	0.0	11.3	17.5	15.6	2.3	0.56	0.0	0.00	2.0
Maximum	15	46	80	48	44					7.5	10.5							314	88	82	8	2.1		0.1	10
Minimum	2	8	31	22	3					6.9	6.2							298	35	33	2	0.5		0.0	5
Number observed	8	8	8	8	8	0	0	0	0	8	8	0	0	0	0	0	0	2	8	8	8	8	7		5
Station A02D																									
Mean	7	47	32	17	15	0.0	0.0	0.0	0.0	7.5	4.4	0	0	0.0	0.0	0.0	0	146	36	33	2	0.1	0	0.1	22
Standard deviation	8.0	53.8	11.7	3.6	13.6	0.00	0.00	0.00	0.00	0.22	0.36	0.0	0.0	0.00	0.00	0.00	0.0	11.3	2.4	2.3	0.3	0.09	0.0	0.19	1.5
Maximum	21	162	57	24	43					7.9	5.0							154	39	36	3	0.3		0.5	24
Minimum	1	2	21	13	3					7.2	3.8							138	32	30	2	0.0		0.0	20
Number observed	7	8	8	8	8	0	0	0	0	8	8	0	0	0	0	0	0	2	8	8	8	8	0	7	5
Station A02E																									
Mean	2	18	25	16	8	0.0	0.0	0.0	0.0	7.6	4.2	0	0	0	0.0	0.0	0	137	34	32	2	0.1	0	0.0	21
Standard deviation	1.6	20.8	5.2	2.3	6.9	0.00	0.00	0.00	0.00	0.31	0.00	0.0	0.0	0.00	0.00	0.00	0.0	1.4	2.3	2.3	0.3	0.00	0.0	0.00	5.6
Maximum	6	56	36	20	23					8.1	5.0							138	37	35	3	0.2		0.1	28
Minimum	1	2	19	13	2					7.3	3.8							136	31	29	2	0.1		0.0	15
Number observed	8	8	8	8	8	0	0	0	0	8	8	0	0	0	0	0	0	2	8	8	8	8		7	5
Station A020																									
Mean	14	28	29	18	10	0.0	0.0	0.0	0.0	7.4	5.4	0	0	0	0.1	0.0	0	134	37	33	4	0.2	5	0.4	23
Standard deviation	56.8	24.2	4.0	2.6	5.2	0.00	0.00	0.00	0.00	0.19	1.93	0.0	0.0	0.00	0.33	0.00	0.3	14.1	2.7	2.2	1.8	0.24	0.4	0.59	3.5
Maximum	345	75	43	25	30					8.0	12.5				2.0	0.0	2	144	41	36	7	1.4	7	1.6	27
Minimum	0	3	21	13	2					7.1	2.8				0.0	0.0	0	124	33	31	2	0.1	5	0.1	16
Number observed	36	7	35	35	35	0	0	0	0	37	35	0	0	0	35	35	35	2	7	7	7	34	34	6	30
Station A02P																									
Mean	38	75	78	19	58	0.0	0.0	0.0	0.0	7.1	4.3	0	0	0	0.5	0.0	0	129	0	0	0	0.6	0	0.2	19
Standard deviation	58.9	135.3	97.4	3.6	95.1	0.00	0.00	0.00	0.00	0.26	1.64	0.0	0.0	0.00	1.41	0.00	1.4	21.2	0.0	0.0	0.0	0.92	0.0	0.00	5.4
Maximum	155	390	284	25	261					7.6	6.6				4.0		4	144				2.5		0.2	26
Minimum	3	2	24	16	3					6.8	1.1				0.0		0	114				0.1		0.1	14
Number observed	10	9	9	9	9	0	0	0	0	10	9	0	0	0	8	8	8	2	0	0	0	9	0	2	4
Station A02R																									
Mean	144	366	176	24	151	0.0	0.0	0.0	0.0	6.8	20.9	0	0	0	4.8	2.9	1	0	0	0	0	3.4	0	24.4	12
Standard deviation	123.9	255.0	58.4	10.2	51.6	0.00	0.00	0.00	0.00	0.28	27.20	0.0	0.0	0.00	5.83	5.04	1.4	0.0	0.0	0.0	0.0	2.32	0.0	22.93	2.2
Maximum	644	875	277	45	243					7.2	99.9				19.1	15.1	4					6.8		68.0	15
Minimum	1	74	81	10	68					6.3	1.8				0.0	0.0	0					0.1		0.0	10
Number observed	27	17	21	21	21	0	0	0	0	29	18	0	0	0	9	9	9	0	0	0	0	18	0	27	4

NOTE: See end of table for footnote.

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Table 11 (Contd)

	BOD	COD	Total carbon	Inorganic carbon	Organic carbon	RDX/HMX TNT	RDX	HMX	TNT	pH	Nitrates	Turbidity	Acetone	Cyclohexanone	Total nitrate	Ammonia nitrogen	Organic nitrogen	Dissolved solids	Total hardness	Calcium hardness	Magnesium hardness	Total phosphate	Chloride	Settleable solids	Water temperature
																								ml/l	°C
Station B02A																									
Mean	202	252	159	13	145	13.8	9.5	2.6	1.9	6.2	5.0	15	24	18	7.5	0.7	6	190	44	41	4	0.1	0	0.1	23
Standard deviation	165.7	202.1	199.9	5.0	201.6	10.83	8.72	1.65	2.70	0.88	2.51	4.5	53.4	380	12.67	1.00	12.2	8.4	1.3	0.9	1.0	0.09	0.0	0.09	2.9
Maximum	694	515	1260	21	1252	42.0	38.7	7.5	12.7	7.2	15.0	23	264	212	54.5	3.6	51	196	46	42	5	0.3		0.2	26
Minimum	0	11	41	3	27	0.0	0.0	0.0	0.0	4.4	1.1	10	0	0	0.0	0.0	0	184	42	39	3	10.0		0.0	15
Number observed	39	10	37	37	37	37	37	33	37	38	38	7	33	33	38	38	38	2	8	8	8	36	0	8	24
Station B02B																									
Mean	209	482	120	14	105	11.4	8.1	3.2	0.4	5.9	5.1	16	19	16	4.2	0.3	3	187	43	39	5	0.1	0	0.6	24
Standard deviation	174.7	237.2	74.2	5.1	76.6	11.29	9.26	2.81	0.87	0.89	3.02	5.3	28.8	22.91	5.52	0.61	5.4	9.8	2.6	2.8	1.6	0.09	0.0	0.55	3.1
Maximum	683	864	206	24	456	43.6	33.5	12.4	3.6	7.4	15.0	25	125	121	28.0	2.2	28	194	49	44	7	0.4		1.5	28
Minimum	16	171	34	4	21	0.0	0.0	0.0	0.0	4.2	1.3	10	0	0	0.0	0.0	0	180	41	35	3	0.0		0.1	14
Number observed	39	10	37	37	37	37	37	33	37	38	38	7	34	34	38	38	38	2	8	8	8	35	0	8	26
Station B02C																									
Mean	27	36	40	19	19	0.8	0.7	0.2	0.0	7.5	5.1	13	0	0	1.3	0.0	1	205	48	44	3	0.0	0	0.2	22
Standard deviation	18.7	22.6	10.1	6.2	13.0	1.05	0.95	0.28	0.00	1.08	1.37	2.1	0.0	0.28	2.14	0.17	2.1	29.6	3.2	2.9	0.8	0.00	0.0	0.30	3.5
Maximum	60	73	59	28	43	3.2	2.6	0.6	0.1	7.7	6.7	16		1	7.0	0.5	7	226	53	49	4	0.2		0.9	25
Minimum	3	3	26	12	3	0.0	0.0	0.0	0.0	6.9	2.5	9		0	0.0	0.0	0	184	44	42	2	0.0		0.0	17
Number observed	12	10	12	12	12	12	12	8	12	12	12	7	12	12	12	12	12	2	8	8	8	12	0	8	4
Station B02D																									
Mean	40	101	40	17	22	0.2	0.0	0.4	0.0	7.4	15.7	12	0	0	1.3	0.3	1	168	44	41	3	0.8	0	1.0	22
Standard deviation	25.3	111.1	12.1	4.0	13.9	0.60	0.00	0.80	0.00	1.10	31.61	3.2	0.0	0.00	0.94	0.44	0.5	31.1	4.9	6.0	1.4	1.20	0.0	1.51	1.1
Maximum	85	388	65	26	53	1.8		1.8		10.2	99.9	17			3.1	1.1	2	190	49	46	6	3.3		4.5	23
Minimum	11	35	25	12	5	0.0		0.0		6.2	2.1	8			0.0	0.0	0	146	33	27	1	0.1		0.0	21
Number observed	9	9	9	9	9	9	9	5	9	9	9	7	8	8	7	7	7	2	8	8	8	9	0	8	3
Station B02E																									
Mean	8	24	24	15	8	0.0	0.0	0.0	0.0	7.2	26.0	13	0	0	0.3	0.1	0	170	47	43	4	0.1	0	0.2	19
Standard deviation	4.7	19.0	6.9	2.6	7.8	0.00	0.00	0.00	0.00	0.43	19.43	2.8	0.0	0.0	0.43	0.30	0.3	42.4	3.1	3.4	1.0	0.17	0.0	0.14	1.1
Maximum	16	60	41	18	27					7.8	71.0	17			1.0	0.8	1	200	52	49	6	0.5		0.4	20
Minimum	3	4	17	13	3					6.6	11.8	11			0.0	0.0	0	140	43	40	3	0.0		0.1	18
Number observed	9	9	9	9	9	0	0	0	0	9	9	7	0	0	7	7	7	2	8	8	8	9	0	8	3
Station B02G																									
Mean	155	256	59	14	45	2.6	1.2	2.1	0.0	6.6	5.7	12	0	1	2.1	0.6	1	206	42	39	4	0.1	0	0.5	27
Standard deviation	103.9	220.5	21.4	2.5	22.3	3.42	1.51	2.24	0.00	0.71	1.24	1.6	0.0	2.66	1.94	0.69	1.6	56.5	2.6	2.0	1.0	0.19	0.0	0.50	2.0
Maximum	334	693	82	18	73	10.3	4.6	5.7		7.3		14		8	5.9	1.8	5	246	48	43	5	0.6		1.2	29
Minimum	63	55	28	10	12	0.0	0.0	0.2		5.0	2.8	9		0	0.0	0.0	0	166	39	36	3	0.0		0.1	25
Number observed	9	9	9	9	9	8	8	5	8	9	9	7	9	9	8	8	8	2	8	8	8	9	0	8	3
Station B03B																									
Mean	11	17	30	18	11	1.1	1.0	0.2	0.0	9.0	15.4	11	0	0	1.3	1.0	0	225	48	45	3	0.2	23	0.3	22
Standard deviation	41.1	13.3	4.7	2.6	4.9	4.24	3.55	0.77	0.00	9.74	8.68	2.4	1.0	0.00	6.09	5.76	0.7	29.6	3.0	3.4	0.7	0.19	11.3	0.09	4.2
Maximum	261	41	39	25	25	21.4	17.6	3.8		9.5	39.5	16	4		37.6	35.6	4	246	53	51	4	1.0	59	0.4	28
Minimum	1	2	20	14	3	0.0	0.0	0.0		7.0	4.4	9	0		0.0	0.0	0	204	43	39	2	0.0	5	0.1	13
Number observed	39	10	37	37	37	25	25	25	25	38	38	7	22	22	38	38	38	1	8	8	8	36	35	8	26

* All measurements are in milligrams per liter except pH, settleable solids, and water temperature.

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measurement of DO was recommended by USAEHA for all HAAP discharges from industrial treatment facilities.[13] Conversely, in open-channel ditches which carry cooling water from the production lines in area B, DO is measured and it is not a problem, but these ditches are heavily colonized by black fly larvae, which, as adults, are a pest (Mr. Lady, HDC, personal communication).

There have been many attempts to evaluate the impacts of wastewater discharges from HAAP areas A and B on water quality in the Holston River.[2, 11, 12, 14, 15] However, most surveys have been inconclusive because HAAP is but a small portion of the pollution problem in the upper Holston River, and the quality and quantity of HAAP's discharges are highly variable, as shown by the ranges (especially BOD) in table 11. The chemical composition of the HAAP wastewaters places an additional oxygen demand on the river. The Environmental Protection Agency recognizes that unilateral pollution abatement by HAAP will cause little improvement of the water quality in the upper Holston River,[2, 11] because there are other large pollution sources upstream. (See area water quality for detail.)

In a limited biological survey, USAEHA concluded that, although no obvious effects on aquatic organisms were found resulting from area A discharges, potential effects were probably obscured by poor water quality upstream.[7,16] The data indicated that Arnott Branch, which receives cooling water and wastewaters from the acid area, was degraded to a condition of "moderately polluted" as a result of these discharges.

Dye studies confirmed that surface flow was generally linear so that the North and South Forks of the Holston River remain separated until river mile 136 downstream of the area B manufacturing area.[14] This North Fork is distinguished from the South Fork by high levels of chloride, conductivity, and hardness. In this area, effluents from surface ditches and pipes enter the river, and it is likely that these outfalls hug the north shore of the river and flow without mixing beyond Arnott Branch. Because DO measurements in the river made during the morning and afternoon were low under conditions of turbulent flow, Water and Air Research, Inc., hypothesized that DO drops to less than 1.0 mg/l during an early morning low-flow period. These nearly anoxic conditions, which are detrimental to aquatic life, are aggravated by additional oxygen demands from HAAP wastewaters. In the immediate vicinity of the waste outfalls, Water and Air Research, Inc., found significant increases in heterotrophic biomass and reductions of chlorophyllous species. They related these changes to toxic and eutrophic effects of RDX and its associated residues.[14] This study did not address the effects of area A wastewaters on water quality.

F. Natural Resources.

1. Flora.

A definitive study of the flora of HAAP has not been conducted. However, members of the Wildflower Club of Kingsport, Tennessee, have compiled a list of wildflowers identified during field trips on the facility (Mr. Joe Taft, Naturalist, Bays Mountain Park, personal communication). This list indicates the great variety of plant-life indigenous to HAAP. Appendix A lists the types of wildflowers found on HAAP, including those found during our visit (April 1976).

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Inasmuch as HAAP occupies a portion of Bays Mountain and is contiguous to Bays Mountain Park, the flora of these areas will probably reflect much of the flora of HAAP. Jonathan Wert, Interpretive Service, Bays Mountain Park, conducted a survey of the ferns and trees found in the Bays Mountain Park area.[17,18] Emerson Roller, East Tennessee State College, Johnson City, Tennessee, also conducted a survey of the flowering plants and ferns of Bays Mountain.* Each survey offers an excellent base from which future studies of the flora of HAAP could be conducted. These lists of plants were combined with other pertinent lists in appendix B.

The Forest Management Plan for HAAP offers an abbreviated list of the trees of HAAP.[19] When the plants in this list are compared to the plants identified by Wert and Roller, a high degree of similarity is evident (appendix B). Of the approximately 150 species of plants listed by the Wildflower Club, six species are considered by various sources to be rare or endangered. Dr. Aaron Sharp, University of Tennessee at Knoxville, classifies *Cypripedium acalue* (lady's slipper), *Disporum maculatum* (nodding mandarin), *Panax quinquefolius* (ginseng), *Polygala paucifolia* (fringed polygala), and *Symplocarpus foetidus* (skunk cabbage) as rare plants.[20] These form the basis of the Tennessee protected plants. The United States Department of Agriculture also considers the above plants rare and added *Liparis lilifolia* (large twayblade) to the list.** These plants are included on the Federal protected plant list. Furthermore, Taft considers lady's slipper and *Orchis spectabilis* (showy orchis) rare plants in eastern Tennessee (personal communication, 1976). These have been identified on HAAP by the Wildflower Club (appendix A).

Consideration was given to the ferns of Bays Mountain in the studies conducted by Wert and Roller and most of the ferns identified in the studies are probably indigenous to HAAP (Joe Taft, personal communication).

Lichens are not included in any of the studies, and any future studies should consider Skorepa's catalog of the lichens reported from Tennessee,[21] Phillips' foliose and fruticose lichens from Tennessee,[22] and Dey's new lichens of the Appalachian Mountains.[23] Also, studies on the bryophytes of HAAP should consider Sharp's keys to Tennessee ferns and his studies of eastern Tennessee bryophytes[24,25] and Shaver's study of the ferns of the eastern central states.[26] Additionally, Shanks and Sharp[27] have produced a summer key to the trees of eastern Tennessee, available through the University of Tennessee at Knoxville, Tennessee.

The geophysical characteristics of HAAP are not unusual for northeastern Tennessee. However, due to the semiprotected nature of the facility, an unusually rich flora has developed within its confines. The area south of the Holston River in which ammunition is stored comprises the portion of Bays Mountain occupied by HAAP. This area is characterized by steep cliffs, gorges, small plateaus, and floodplains, with the walls of the cliffs and gorges composed of limestone. The walking fern, *Camptosorus rhizophyllus*, must have a limestone surface on which to grow. This plant was observed clinging tenaciously to the walls of several gorges in the magazine areas.

Although the depth of the streams in the gorges was approximately 1 to 2 feet at the time of our visit, physical evidence indicated a high-water mark of about 5 feet. High water

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*Roller, Emerson J. A Survey of the Flowering Plants and Ferns of Bays Mountain. Unpublished Thesis. East Tennessee State College, Johnson City, Tennessee. August 1954.

**Letter from Mr. Billy F. Headen, Acting State Resources Conservationist, Soil Conservation Service, US Department of Agriculture, Nashville, Tennessee, to Dr. F. Prescott Ward, Ecological Research, Edgewood Arsenal, Maryland, 4 December 1975.

occurs during early spring runoff from Bays Mountain, causing a wet, boggy environment between the points where the streams leave the gorges and enter the Holston River. This wet, lowland environment is typical of the areas in which skunk cabbage is found.

The plateaus are vegetated with cultivated pines or they are open meadows. The open meadows are typical of the environment in which ginseng is found. The occurrence of these two rare species should be documented so that future management practices can protect their habitats. The forested areas south of the Holston River are in cultivated pines, cultivated hardwoods, and natural hardwoods. The natural hardwood forests are predominantly oak and maple species.

2. Fauna.

The Fish and Wildlife Management Plant contains a list of common names of mammals known to exist on the installation. All of these are included in a checklist of 27 mammal species found in Bays Mountain Park, which borders the installation to the southeast. The eastern woodrat (*Neotoma floridana*), which is included on the checklist, is also listed among the wildlife in need of management by the Tennessee Wildlife Resources Agency. A checklist of birds from Bays Mountain Park includes 82 species, 46 of which were seen at the installation on 4 April 1976. There is also a list of 100 species of common insects and a list of 24 species of butterflies known to exist in the same park.*

During our visit, we met with Dr. Fred Alsop (ornithologist, Tennessee State University, Kingsport) and Ms. Marcia Davis (biologist, Tennessee State University, Kingsport) to discuss biological work that had been conducted in the area. Both Dr. Alsop and Ms. Davis were permitted to accompany our team during a field study. More than 30 birds were sighted or identified by their calls, including the American bittern (*Botaurus lentiginosus*), a great-horned owl (*Bubo virginianus*), the common goldeneye (*Bucephala clangula*), the bufflehead duck (*Bucephala albeola*), and the ring-necked duck (*Aythya collaris*), which indicates that there is a variety of undisturbed habitats at HAAP. Dr. Alsop, a nationally recognized authority, stated that managed forest land and open fields of HAAP should provide excellent habitats for nesting by two endangered bird species: the grasshopper sparrow (*Ammodramus savannarum*) and Bachman's warbler (*Vermivora bachmanii*). The former is protected in Tennessee and the latter is protected by the Federal Government.

A list of 27 species of mammals found in the Cumberland mountains up to 2,000 feet in elevation is available.[28] Another source is the observations of mammals in Johnson and Carter counties, Tennessee,[29] which includes species at elevations of 3,000 to 4,000 feet. Also available are the handbook and field guide for mammals of North America[30] and Eastern United States.[31] The 1972 preliminary list of birds of Tennessee by Alsop[32] (an update of Ganiers previously-published list[33]) does not include distributions or relative abundances of these species. A list of reptiles and amphibians was compiled in association with a study of water quality in the Obey River, its tributaries, the Eastern Highland River, and the Cumberland Plateau in Tennessee.[34]

*Further information on the indigenous faunal resources can be found in references in the bibliography.[28-34]

Macroinvertebrates were collected in the South Fork of Holston River, beginning at the downstream end of Long Island and 4/10 mile up the North Fork of the Holston River during June through September 1975, using natural and artificial substrate samplers.[14] The data were used in a comparative manner to examine the effects of munition production wastes. Oligochaetes were the dominant benthic macroinvertebrates collected. These organisms are generally considered tolerant of high organic and nutrient concentrations and depressed oxygen levels. Chironomidae, *Physa* spp., Sphaerium spp., and *Planaria* were also abundant and are tolerant of nutrient and organic pollution. Their presence confirms Smock and Stoneburners[16] findings of eutrophic conditions in the Holston River. Water and Air Research, Inc., concluded that the effects noted on macroinvertebrate populations might have resulted from RDX plus associated carbon and nitrogen compounds. They suggested that community alterations might occur more from the effluent-associated carbon and nitrogen compounds than from RDX/HMX, considering the high toxic threshold of RDX/HMX measured for various invertebrates in acute bioassays conducted by Bionomics.[35]

3. Geological Resources.

The HAAP region contains two physiographic provinces which were once plains areas. The Tennessee River and the uplifts of Bays Mountain during the Carboniferous period have caused much erosion, folding, and faulting in the rock formations which are principally limestone, sandstone, and shale. The presence of much porous rock makes the drainage patterns somewhat indefinite. Limestone sinks are common through this area, and several have been identified along US Highway 11-W, bordering HAAP. These solution streams often form caverns, such as the one located in area B. Along the river there are high cliffs west of the magazine bridge where the cave opens. Bays Mountain is underlain by Tellico sandstone, which consists of interbedded calcareous sandstone and shale; Bays sandstone, which is calcareous; and Clinch sandstone, which is noncalcareous. The erosion of the mountain ridge during the Mississippian era has exposed the sandstone which predominates the upland soil series.[1]

Although sand is abundant, its complex structure and relative inaccessibility make it generally unsuitable for economic development.[36] Limestone of a high calcium content was formerly quarried on the western edge of HAAP. The quarry was closed after construction of HAAP and the area is now used as a landfill. Other potential mineral resources in this area include shales and zinc. The shales are abundant and, according to the US Bureau of Mines, Norris, Tennessee, a few shales of the Nolichucky, Rogersville, and Pumpkin Valley formations could be used in the manufacture of a lightweight aggregate used for construction and backfills. Currently, there is no commercial use of these minerals in the area.

Data from the soil survey interpretations of each soil type were used to identify the engineering capabilities, the hydrological properties, and the erosion characteristics of each soil series found on HAAP.* Soil series with similar descriptions and construction limitations were grouped together as critical areas. The interpretations here are general and cannot be substituted for on-site soil surveys and professional consultation with Soil Conservation Service prior to initiating construction and maintenance activities. However, the soil maps and the following descriptions should be useful, in combination with other maps included in this report, to locate potential areas for development, management, and maintenance in the existing plant area.

*The information presented here was obtained from an analysis of data provided by the Soil Conservation Service district conservationist, Mr. Joseph Patton, Rogersville, Tennessee.

Major portions of the site soils have been modified for construction purposes in the manufacturing areas of plant B and plant A, with the result that these areas are now a mixture of surface and subsoils along with construction fill materials that were not classified by Soil Conservation Service.

The slope distribution can be obtained from the original soil map and be referenced to topographic maps contained in this report. In general, as the slope increases, the suitability of the land for construction and agricultural uses decreases because erosion becomes more severe.

The Dewey and Decatur soil series consist of deep, well-drained soils on uplands which are underlain by limestone. These soils have shallow water tables, and sinkholes frequently occur. The occurrence of sinkholes along the northwestern plant boundary corresponds well with the distribution of these soils. Seepage problems limit their use for ponds or landfills.

The Etowah and Clarksville soils, found on steep slopes, are subject to severe erosion. Etowah is associated with stream terraces and is well-drained. The Clarksville soils contain cherty silt loam which causes them to be droughty (excessively drained). The droughty nature of Clarksville soils makes them somewhat unproductive. These soils are locally uncommon and are found in the vicinity of the main gate.

The Dandridge, Jefferson, Needmore, Nella, and Talbott soils are well-drained to excessively-drained, clay-like residue from calcareous shales on uplands. They are most abundant on the mountain slopes in the magazine area. Development is limited in these soil series by shallow bedrock, which outcrops commonly in the Talbott series. When the vegetation is removed from any of these soils, erosion and mudslides are common. These are the predominant soils of the ridge environments of the area, and this series is poorly suited for any construction or management because it is quite fragile. The highest rating for these soils is good for woodland/wildlife habitats in the Needmore and Talbott series. Dandridge soils are the most abundant on the facility. Dandridge, Jefferson, and Talbott soils also occur on moderate slopes around the administration buildings.

The Greendale, Hamblen, Holston, Sensabaugh, and Statler soil series consist of deep, well-drained soils, formed in loamy alluviums on bottomlands and low stream terraces. Construction on such sites is limited by occasional flooding, seepage, and apparent high water tables between December and March in the Greendale series. Prior to flood control and river control, many areas of these soil types were flooded each year. These occur somewhat randomly along the permanent drainage of the plant area.

The Altavista, Cloudland, Dunmore, Staser, and Taft soil series are poorly- to moderately-drained soils which occur on uplands and rolling hills to river banks (Staser). All of these soils have poor drainage or are frequently inundated by flooding and have perched water tables from 0.5 to 4.0 feet deep between December and March. Because the water tables are perched (especially Altavista, Taft, and Staser), these soils remain wet and are unsuited for most construction or agriculture without some drainage. The islands and river banks within the plant are largely of the Staser soil series, a typical alluvial soil.

The steep slopes and peaks of Bays Mountain are covered by Muskingham soils which consist of shallow, well-drained soils underlain by sandstone. These soils are subject to severe erosion when the vegetation cover is removed or killed by herbicides. Because the slope

exceeds 50% in most of this area, a cleared zone bordering the security fence cannot be maintained without high maintenance costs and possible erosion damage to the fence itself. Although some hardwood species grow in this area, they cannot be harvested without considerable damage to the area.

The principal soils mapped for HAAP are listed in table 12. Data were not available for all soil types on HAAP, but those not listed in table 12 (Nella and Sensabaugh) may be considered to have characteristics similar to other soil series with which they were grouped in the previous discussion. The woodland suitability groups for the soil series have been derived from a US Department of Agriculture progress report;[37] brief descriptions of each group are included (appendix C). The progress report provides additional explanatory data which discuss the tree species and management practices which should be employed for each woodland group.

4. Archeological and Historical Resources.

There are no cemeteries within the boundaries of HAAP in areas A or B.

The Kingsport chapter of the Tennessee Archaeological Society has carried out a series of excavations on the Holston River within the boundaries of the installation, near gate 57, adjacent to the sewage treatment plant. In conversation with one of the members of the chapter, we learned that further work at this site was abondoned last year since "little or nothing" was uncovered.

A visit to this area revealed that the excavations occupied nearly an acre. The ground was littered with stone flakes and fire-burned rocks, indicating that it was at one time the scene of habitation and tool-making activity. Further inspection resulted in the recovery of 50 or more pottery shards of varying designs and a finely-worked projectile point. These findings cast some doubt upon the quoted remarks of the chapter members. Further professional archeological examination should be conducted at this site prior to any construction or excavation there.

IV. INSTALLATION ACTIVITIES WITH A POTENTIAL FOR AFFECTING INSTALLATION RESOURCES.

A. Public Utilities.

1. Electricity and Steam.

Holston Army Ammunition Plant purchases electricity from Kingsport Power Company, Kingsport, Tennessee. In FY75, 86,712,000 kilowatt hours were purchased and 230,376 tons of coal containing 1% to 2% sulfur were burned in the steam-producing plants (Mr. Charles Skidmore, Staff Assistant, HDC, personal communication). Figures 4 and 5 show the locations of boilers for area A (building 8) and area B (buildings 200 and 222), respectively. Building 222 contains three boilers which are inactive due to the uncertainty of natural gas supply. Building 8 has six stoker boilers and one pulverizer boiler which produce 100,000 and 190,000 pounds of steam per hour for each boiler type, respectively. Building 200 has four stoker boilers and two pulverizer boilers. The stoker boilers each can produce 130,000 pounds of steam per hour.

There is no stack-monitoring program for the steam-generating plants, except for opacity monitors (Mr. Robert Hash, Chemist, HDC, personal communication). Continuous

Table 12. Principal Soil Series from Holston Army Ammunition Plant

Land suitability classification	Soil map number	Soil series	Soil information sheet number	Woodland suitability
I1	2	Huntington silt loam	14	207
	3	Greendale silt loam	14	207
	50	Statler silt loam	1	207
	85	Staser silt loam	14	207
	48	Sequatchie silt loam - gravelly silt	14	207
I2	11	Whitesburg silt loam	14	2W8
	5,86,94	Landside silt loam and cherty silt loam	14	2W8
IIe1	17B1	Minvale silt loam and cherty silt loam	1	307
	42B	Holston loam	2	307
	48B1	Sequatchie silt loam to gravelly silt loam	1	207
IIe2	44B1	Cloudland loam	6	307
	59B2	Dewey silt loam	3	
IIw1	151	Altavista silt loam	14	2W8
		Hamblen silt loam	14	2W8
IIIe1	42C	Holston loam	2	307
	16C1	Etowah silt loam	1	207
IIIe2	66C2,C3	Dunmore silt loam	3	307
	59C2	Dewey silt loam	3	307
IIIe3	40C1,2	Nolichucky silt loam to gravelly fine sandy loam	2	307
	42C1,2	Holston loam and gravelly loam	2	307
IIIw1	288	Melvin silt loam	17	2W9
IIIw2	46	Taft silt loam	18	3W8

Table 12 (Contd)

Land suitability classification	Soil map number	Soil series	Soil information sheet number	Woodland suitability
IIIw3	46	Tyler silt loam to loam	18	3w9
IVe1	38D	Dewey silt loam	3	307
	42D	Holston loam	2	307
	58D	Decatur silt loam and gravelly silt loam, 2%-22% slopes	3	307
	59D2	Dewey silt loam	3	307
	66D2	Dunmore silt loam	3	307
IVe3	76C2	Needmore silt loam	7	3C2
	71C2	Talbott silt loam	7	3C2
	25E1	Jefferson silt loam to fine sandy loam	2	3r8
VIe1	59E2	Dewey silt loam, 5%-30% slopes	3	4c3e
	65D1	Clarksville cherty silt loam, 2%-15% slopes	4	3c8
	66E2	Dunmore silt loam	3	3r8
VIe2	71D2	Talbott silt loam	7	3c2
	75D2	Sequoia silt loam	7	302
VIe3	77D,D3,E1	Dandridge shaly silt loam	9	4d3
	79D1	Litz shaly silt loam	9	3f8
VIs1	27D1	Jefferson cobbly loam	10	3X8
	101C	Talbott rock-outcrop complex	11	4X3
VIIe1	77F	Dandridge shaly silty clay	9	4d3
		Litz silt loam		
VIIs1	101E	Talbott rock-outcrop complex	11	4X3
	102E	Talbott rock-outcrop complex	11	5X3
	100	Holston urban land complex		
		Muskingham stony		5X3
VIIs2		Pits and fills		

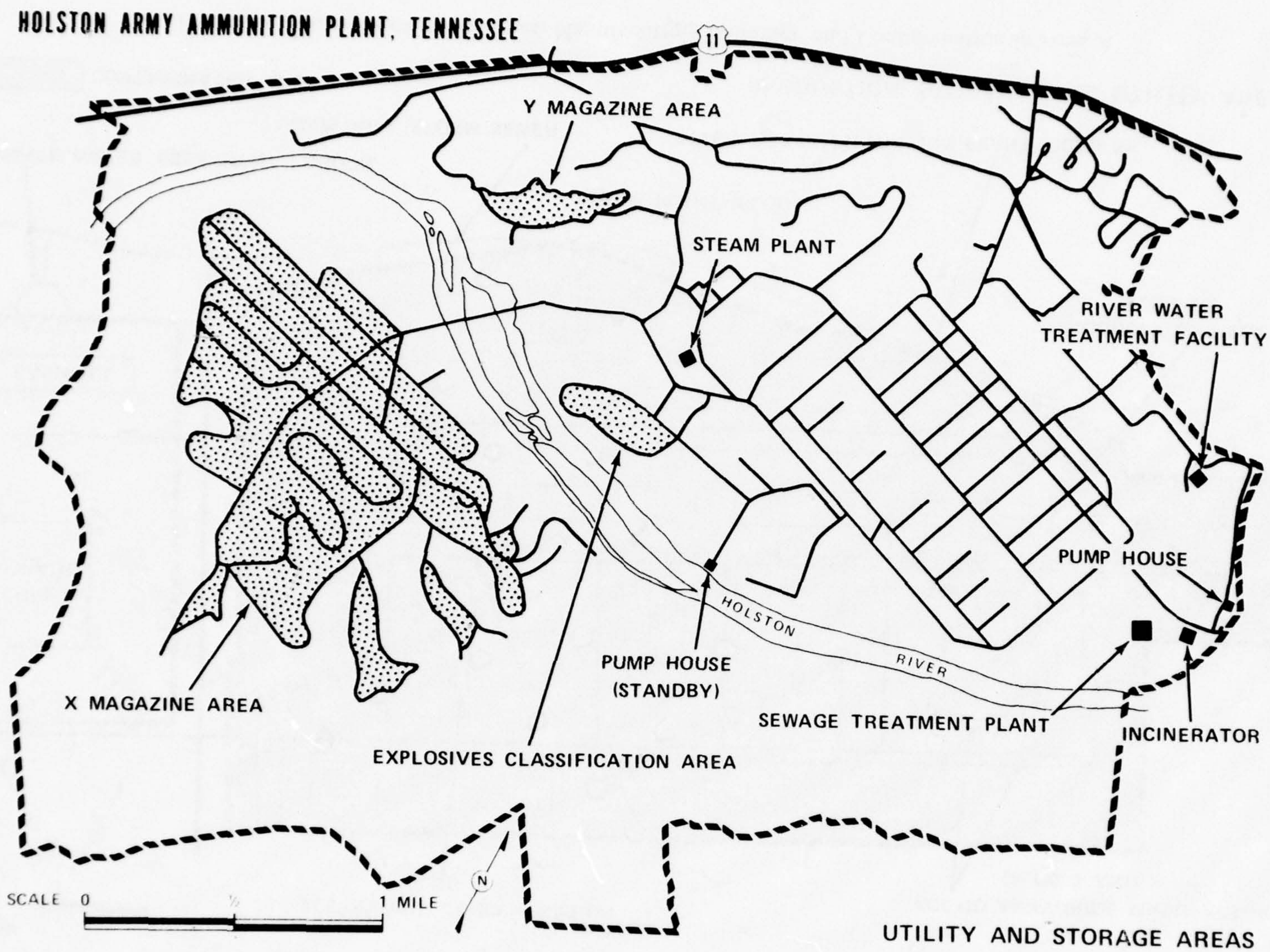


Figure 4. Locations of the Utilities and Storage Areas in Area B

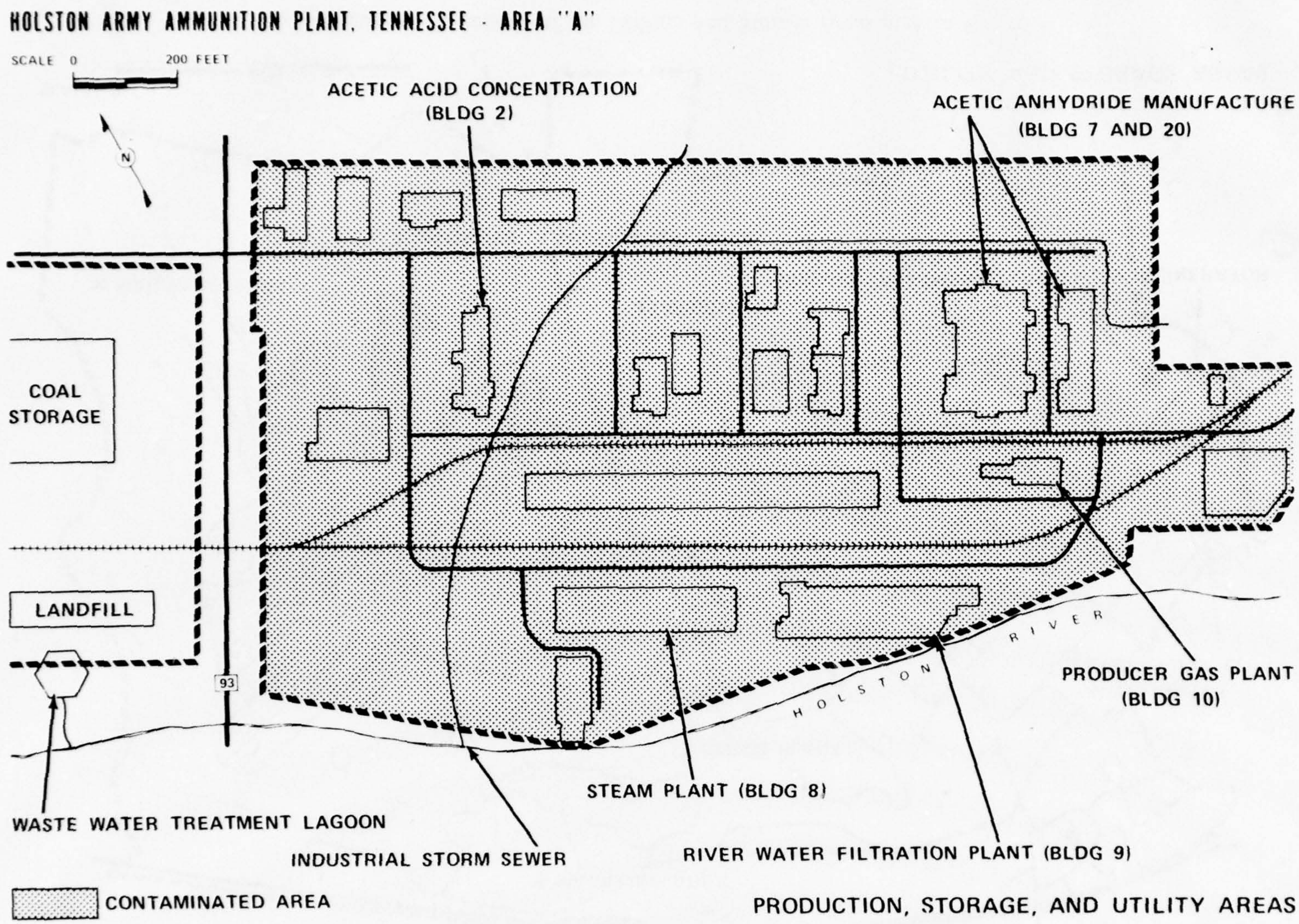


Figure 5. Locations of the Utilities, Manufacturing Buildings, and Contamination in Area A

blowdown from buildings 200 and 222 is discharged into a settling pond before it enters Arnott Branch. Blowdown from building 8, area A, is similarly detained before it enters the Holston River. This currently inadequate treatment for solids and heat will be improved in HAAP scheduled phase 2 pollution abatement program (Mr. Robert Brewer, Mechanical Engineer, HDC, personal communication). The boiler additives are shown for each area in table 13.

Table 13. Amounts of Boiler Treatment Chemicals Added to Area A and Area B Boilers in FY75

Chemical	Amount added to boiler (thousand pounds)	
	Area A	Area B
Rock salt	185.5	514.4
Disodium phosphate	2.1	9.1
Sodium sulfite	1.2	6.3

The high concentrations of solids are visible in the South Fork of the Holston River and further degrade water quality. The discharge temperature of the cooling and blowdown waters is 7° to 10°C above ambient levels. These conditions may stimulate the growth of noxious algae and eliminate desirable species.[38]

2. Water Utilization.

For FY75, 99.8% of the total average water demand of 127.82 Mgal/d was pumped from the Holston River and the South Fork by HAAP. Two-tenths of 1% was purchased from the Kingsport municipal water supply (table 14). The locations of pumps and filter houses are shown in figure 4. An average of 13.85 Mgal/d was filtered water used in the industrial process (Mr. Charles Skidmore, personal communication). In area A, water is flocculated with alum, the pH is adjusted with lime, and the water is then chlorinated. At area B, filtered water is prechlorinated to 1.5 ppm, flocculated using alum, settled in primary and secondary basins, and finally gravity-filtered. The filter is composed of an anthracite top layer and four layers of increasingly smaller garnet. The backwash from the gravity filter and the settling ponds goes into a drainage ditch and then to the Holston River (Mr. Howard Quillen, Supervisor, Utilities, Area B, HDC, personal communication). The amounts of chemicals used for water treatment are shown in table 15. Currently, sludges drain to the Holston River. When the new industrial wastewater treatment facility operates, sludges from flocculation will be disposed in a landfill when the settling tanks are cleaned.

3. Sewage.

All sewage from area A is pumped to the Kingsport municipal waste treatment plant. In area B, 0.19 Mgal/d is treated (see figure 4 for the location of the sewage treatment plant.) Primary and secondary treatments are administered by settling ponds and trickling filter. Approximately 80% of the BOD is removed and the dissolved oxygen is near 9 ppm after treatment. The sludge is sold or given to the local farmers. It is rarely dumped in the sanitary landfill (Mr. Quillen and Mr. Lady, HDC, personal communication).

Table 14. Water Consumption at Areas A and B in FY75

Source of water	Amount	Treatment by HAAP	Use
	Mgal/d		
South Fork of Holston River	49.72		
	1.42	Filtered	Process at area A
	48.29		Cooling at area A
Holston River	77.82		
	12.43	Filtered	Process at area B
	65.39		Cooling at area B
Kingsport municipal water treatment plant	0.28	-	Drinking at areas A and B
Total	127.82		

Table 15. Amounts of Chemicals Used for Water Treatment at Areas A and B in FY75

Chemical	Amount used (thousand pounds)	
	Area A	Area B
Alum	96.7 (dry weight)	2625.5 (gallons)*
Lime	38.2 (hydrated)	321.0 (quick lime)
Chlorine	38.2	246.1

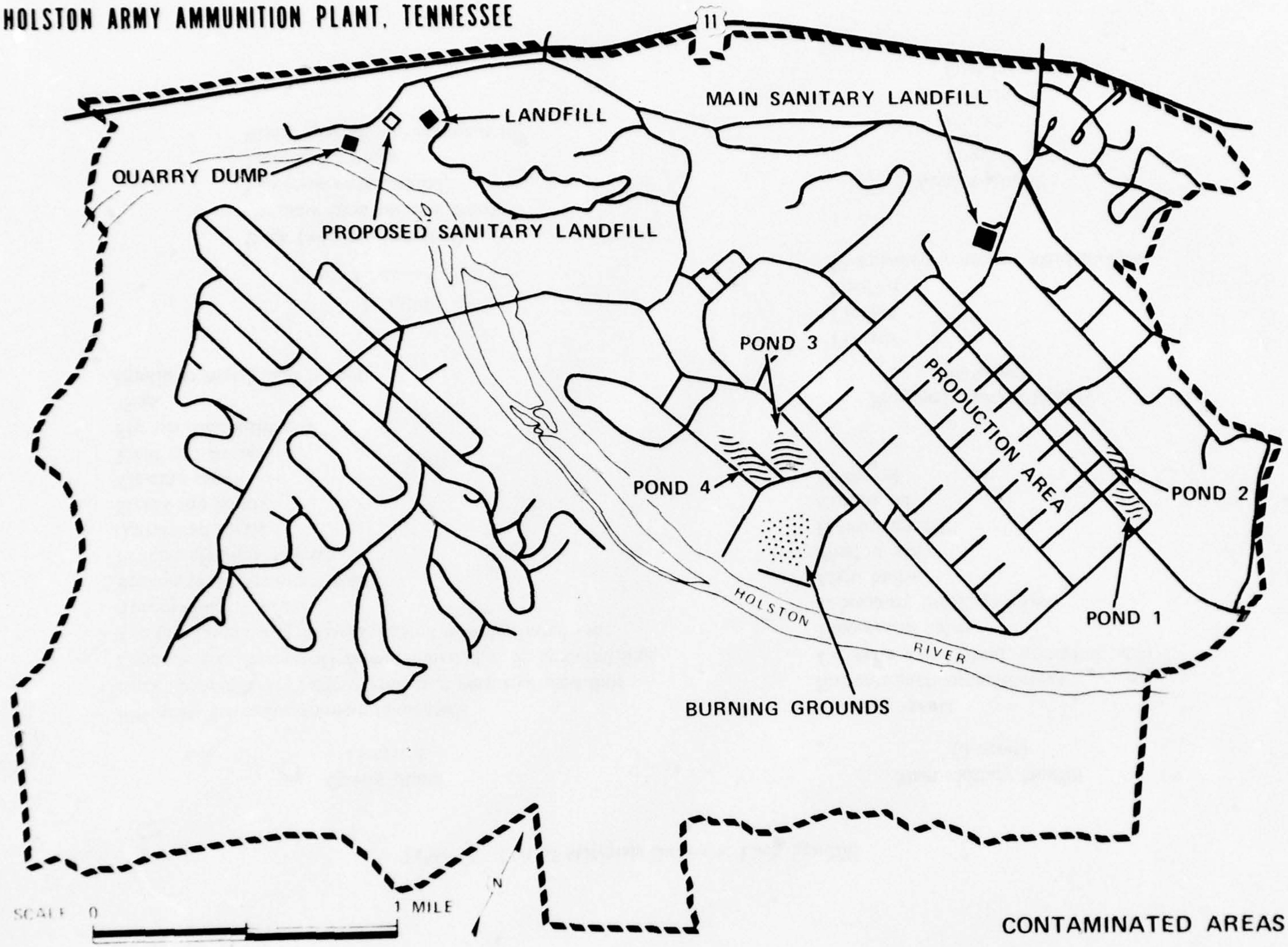
*48% Alum liquid.

B. Solid Waste Disposal.

1. Landfills.

There is one landfill in area A (figure 5) and three landfills and an open dumping area in area B (figure 6). No records were avaliable for the total volume of solid waste disposed of at each site. However, the types of wastes are identified for each landfill in table 16. The main sanitary landfill at area B (3 acres) has been in operation since 1966 and is expected to be used until 1978. Less than 1 acre of the proposed area B sanitary landfill (10 acres total) is currently being used to bury fly ash, coal tar, and cinders from the steam-production facilities. The remaining area is graded, without vegetation. Contractors of HDC are currently using this area to obtain clay. Based on soil survey maps, the new landfill will be located in an area where sinkholes and subsidence are likely. Therefore, borings of the subsurface should be conducted to evaluate this hazard and the threat of groundwater contamination. Even though the clay soil was barren, there was no evidence of erosion because the site is level. The third landfill at area B (2 acres) is located in an old meander of the Holston River, downstream of a dike. Sixty feet of construction materials and trees has been covered with loose soil at this site. After the landfill was in use for an undetermined period, the stream behind the dike went underground and its new course has not been determined. This landfill is in an area susceptible to sinkholes. The

HOLSTON ARMY AMMUNITION PLANT, TENNESSEE



CONTAMINATED AREAS

The entire production and acid areas, along with manufacturing and storage buildings, must also be considered potentially contaminated with acid and/or explosive compounds.

Table 16. List of Materials Buried at Each Landfill

Quarry dump (3 acres)

- Fiberglass insulation (noncontaminated)
- Brick (contaminated) decontaminated with hydrated lime
- Concrete (contaminated) decontaminated with hydrated lime
- Tile (contaminated) decontaminated with hydrated lime
- Automobile batteries
- Broken tools (ferrous metals)
- Fencing (ferrous metals)
- Galvanized metal
- Straps and bands
- Tin-zinc cans
- Trees and stumps
- Fly ash (discontinued)
- Tires
- Unsalable metals and rubber

Landfill (2 acres)

- Brick (noncontaminated)
- Concrete (noncontaminated)
- Tile (noncontaminated)
- Trees and stumps
- Wood scrap (noncontaminated)

Main sanitary landfill (3 acres)

- Cleaning agents
- Solvents (noncontaminated)
- Cafeteria waste (food, nonmetal cans)
- Fluorescent tubes
- Laboratory breakage (glass)
- Light bulbs
- Window glass
- Lubricating oil
- Cutting oil
- Motor oil

Proposed sanitary landfill (10 acres)

- Fly ash
- Cinders
- Coal tar
- Wastewater treatment plant sludges

Area A landfill (1 acre)

- Fly ash
- Cinders
- Coal tar

additional weight of the fill material may cause the land to subside at the landfill site. Landfills sited in such areas are potential sources of groundwater contamination.

A dumping area is located in a former limestone quarry. The various metal and rubber products are covered with soil when the surface of the quarry is filled. Masonry and metal potentially contaminated with explosives are treated with hydrated lime prior to disposal in the landfill (Mr. Joseph Lady, Maintenance and Grounds Division, HDC, personal communication). The only surface drainage from this quarry is toward the Holston River, and there is a potential for leaching of metal and acids into the runoff and the groundwater.

The landfill at area A (1 acre) is a small trench used only to bury fly ash and cinders from the steam-generation plant and coal tar (when it is not burned in the boilers) from the producer gas plant (table 17).

2. Incineration.

There are two incinerators at area B, both in the same building, and none at area A. (See map for locations.) Both are model 2000 Combustall® incinerators with a capacity of 2,000 pounds per hour. The fire is started by a natural gas burner and then is self-supporting with an afterburner for escaping gases. Operation of one incinerator began at the end of November 1974; it is now used approximately once every 9 days. The other incinerator is used as a backup. Tin-zinc cans, office paper, hexamine bags (paper), obsolete-office files, shipping cartons (cardboard), and eyeglasses (plastic) are incinerated. (See table for amounts.) Computer paper and keypunch cards are recycled. Cafeteria waste (food) and infectious wastes are incinerated in the steam boilers since storage is not permissible. Explosives and materiel contaminated by explosives are not incinerated in this incinerator. The Combustall® model 2000 incinerator has been tested by Environment One Corporation for the Corps of Engineers under an FY72 MCA Project, Line Item 4 for HAAP, and was found in compliance with Federal and State air quality standards. There is no monitoring program for its stack emissions. There are plans to install an incinerator to burn explosives (FY74 MCA Project, Line Item 20 for HAAP).

3. Open Burning.

Waste explosives and materials contaminated by explosives and solvents are open burned each day if feasible (figure 6; table 18 shows amount of materials). Waste explosives are placed on a sheet of plastic on the ground in a 3-foot-wide, 3-inch-high strip of variable length. Excelsior strips are used to light the fire. Burning is done only if wind and humidity conditions are suitable and if fire department personnel are present.

Particulates have not been measured; however, the combustion products of waste explosives and plastic are released into the air without treatment. Runoff from this site enters drainage ditches which join the river.

Materials contaminated by explosives such as wood, masonry, and metals from old buildings and containers of explosives are burned; metals are recovered if possible. Most of the noncombustible waste which remains is dumped in the quarry, and some is spread around at the burn site.

Solvents are poured into a 20-foot-square pit in the burning area. The pit contains water and the solvents float on the water and are burned (Mr. Joseph Milner, Safety Office, HDC, personal communication).

Table 17. Refuse and Fly Ash Disposal

Date	Amount of refuse and fly ash disposed of				
	Area B, main sanitary fill	Area A, fly ash, building 8-Y	Area B, fly ash, building 200B	Area A, tar, building 10A	Area B, refuse by landfill
	yd^3				
16 Jan 75	6,300	43	58	97	
17 Feb 75	1,400	38	62	94	
17 Mar 75	1,497	208	32	92	
16 Apr 75	1,270	29	55	113	
15 May 75	1,791	16	24	151	
16 Jun 75*	32*	20	44	93	1,400*
15 Jul 75	48	22	56	96	1,600
18 Aug 75	36	19	38	91	1,526
16 Sep 75	28	16	42	93	1,721
16 Oct 75	39	28	2,064	97	1,645
18 Nov 75	32	16	100	91	1,200
16 Dec 75	37	18	40	93	1,752
16 Jan 76	41	28	45	96	1,340
17 Feb 76	288	38	52	91	1,358
18 Mar 76	114	88	20	93	1,548

*In June 1975, the landfill below the dam in area B was opened and from this date onward refuse that must go into a sanitary landfill went to this site; the other refuse went to the new landfill.

Table 18. Contaminated and Potentially Contaminated Areas

Contaminated areas	Type of contaminant	Capacity	Area	Status
		gal*	acres	
Pond 1	Sodium nitrate sludge	11,166,000	3.61	Filled
Pond 2	Sodium nitrate sludge	9,166,000	2.55	Filled
Pond 3	Sodium nitrate sludge and other chemicals	17,273,000	8.45	Active
Pond 4	Sodium nitrate sludge	39,686,000	11.85	Active

*Ponds 1 and 2 are now covered with earth because the sludge was used for fertilizer manufacture.

Explosives and contaminated materials will be burned in an explosives incinerator and in an incinerator for contaminated materiels when FY74 MCA-project line-item 20 is completed. This project is presently in the design phase.

C. Contaminated Areas.

Production sites A and B (134 and 630 acres, respectively) should be considered potentially contaminated by HMX/RDX and their byproducts.

As an emergency measure (following the destruction of the sodium nitrate processing facility by fire), four holding ponds were dug to hold the production effluent. Their area and capacity are shown in table 19. When ponds 1 and 2 were filled, the contents were reprocessed and the remaining liquid slowly drained, over the course of a year, into the Holston River. These ponds were then filled and seeded. Ponds 3 and 4 are still in use (Robert Hash, personal communication). The proposed industrial treatment facility will be constructed north of the former site of ponds 1 and 2.

D. Manufacturing Emissions.

1. Air Emissions.

The major manufacturing units at HAAP that affect air quality are:

A. Steam production plants.
b. Nitric acid concentration units.
c. Acetic anhydride unit.
d. Producer gas plant.
e. Ammonia oxidation process units.
f. Open burning areas.

The characteristic emissions and applicable standards are summarized in table 19. Open burning is discussed in section IV, B, 2.

Table 19. Characteristics of the Air Emission Sources at Holston Army Ammunition Plant

Location	Operation	Types and amounts of emissions	Standard
Area A, building 8	Central coal-fired heating plant (seven boilers)	Heat input, 903 MBtu/hr Sulfur oxides, 8,020 lb/day Particulates, 16,000 lb/day	1.6 lb/MBtu (2-hr max) 0.18 lb/MBtu (daily)
Area B, building 200 and 222	Central coal-fired heating plant (six boilers)	Heat input, 1,271 MBtu/hr Sulfur oxides, 11,060 lb/day Particulates, 16,000 lb/day	1.6 lb/MBtu 0.18 lb/MBtu
Area B, building 334	Nitric acid concentrators	Nitrogen oxides, 5,220 lb/day	
Area B, buildings 302 and 302B	Ammonia oxidation process units	Nitrogen oxides, 17,000 lb/day	
Area B, figure 6	Two open burning areas	Particulates, 1,410 lb/day	No open burning
Area A, building 10	Producer gas plant	Visible emissions, particulates	20% opacity 5 min/hr (max) or 20 min/day (max)
Area A, buildings 2 and 6	Acetic acid and acid anhydride units	Methyl nitrate, 533 lb/day Solvent vapors, 1,067 lb/day Acid mist, 0.001 lb/hr	Acid mist, 0.009 lb/hr

NOTE: MBtu - Thousand British thermal units.

a. Steam-Production Plants.

The steam-production plants at HAAP are located in building 8 at area A and buildings 200 and 222 at area B. Their capacities and descriptions are detailed in section IV, A. Building 222 is currently on standby status. Building 8 has seven boilers and building 200 has six, with a separate stack for each unit. Only particulates were measured during a 1967 survey because all boilers were fired with low-sulfur coal (0.6%).[8] Boilers 3 and 4, area B, exceeded all applicable particulate emissions during a 1971 survey.[10] Lead was also present in the exhaust gases from boilers at areas A and B. Phenolic compounds were measured from boilers 1 and 5 at area A and were attributed to the frequent burning of producer gas tar as an alternate fuel.

b. Nitric Acid Concentration Units.

The nitric acid and concentration plant in area B (building 334) produces 117,000 pounds per day of 99.5% nitric acid from units 5 and 8. During the 1971 USAEHA air sampling survey,[10] the concentration of acid mist from unit 5 (0.56 gm/ft^3) was greater than twice the Tennessee standard for process emissions (0.25 gm/ft^3).

c. Acetic Acid and Anhydride Units.

In area A, low-grade acetic acid is obtained as a byproduct of acetic anhydride distillation (building 6), and crude acetic acid from acetic acid recovery (B-buildings) in area B is returned to area A for recovery in building 2. This low-grade acetic acid is concentrated by azeotropic distillation (buildings 2 and 6) during which low-grade impurities (acetonitrile, methyl acetate, methyl nitrate, ethyl acetate, propanol, and propyl acetate) are released to the atmosphere (table 19). Acid mist and total acidity emissions from these buildings were less than the Tennessee State standard.[10] Methyl nitrate was measured as NO_x by USAEHA[10] and a subsequent military construction project was scheduled to remove methyl nitrate to acceptable emission levels. Now methyl nitrate is no longer vented to the atmosphere; it accumulates in the solvent and is removed when the solvent is replaced.

d. Producer Gas Plant.

The producer gas plant (building 10) manufactures about 2 million cubic feet of gas each day. The gas is manufactured by the incomplete combustion of coal and is used for fuel in acetic anhydride manufacture. Visible emission has been identified as the most serious air pollution problem associated with this facility. The shortage of natural gas has prevented conversion of this facility, but no pollution abatement projects have been funded to correct this problem. Abatement has been programmed in an FY79 Production Support and Environmental Requirements Program.

e. Ammonia Oxidation Units.

There are 10 ammonia oxidation process units in area B, 4 of which are active. The ammonia oxidation process units produce 61% nitric acid, and USAEHA estimates that they emit 17,000 pounds per day of nitrogen oxides as NO_2.[8] Nitrogen oxides are lost from the exhaust unit (unit 9, building 302) during startup and from the compressor during power recovery. A 1971 survey showed that 67.9 pounds of nitrogen oxides was emitted for each ton of gas that was produced.[10] This rate exceeded the Federal guideline of 5.5 pounds per ton of acid produced. Emission of acid mist and sulfur dioxide was not considered to be significant by USAEHA.[10]

Work on the molecular sieves for one 55-tons-per-day (TPD) unit has been completed. The 300-TPD unit uses extended absorption. These ammonia oxidation process units now comply with the air emission standards for NO_x gases.[39] The combined output of these units would handle approximately 71% of the requirement of nitric acid at mobilization. Three ammonia oxidation process units not equipped with molecular sieves would be needed and NO_x emissions would be in violation at mobilization levels. Evans stated that, for other units, the rate of pollutant discharges varies with production rates,[40] because the ammonia oxidation process units are operated at maximum efficiency although they operate intermittently based on the demand.

2. Water Emissions.

The aqueous emissions from areas A and B have been characterized in detail by USAEHA.[12] In that survey and in subsequent water quality studies,[13-15] the flow rates and pollutant concentrations of the wastewaters were found to be highly variable. Although discharges containing only a few characteristic pollutants were measured at their building source, the proximity of other industrial outfalls and the practice of mixing wastewaters (industrial, cooling, and surface drainage in area A and industrial and cooling waters in area B) has confounded all efforts to interpret the effects of HAAP wastewaters on the receiving stream.

In area A, surface drainage from the main tank farm area, where organic components and products are stored, and principal roadways in the production area is discharged through a storm sewer directly to the Holston River. During dry weather, flow in this sewer consists of condensate, leakage, and washdown water from the main tank farm and producer gas plant (building 10). The remaining storm water runoff from area A is carried concurrently with industrial wastewaters, process water from American Saint Gobain Glass Works Plant, and storm runoff from Kingsport. Water quality for the two tributaries' sampling stations (10 and 11) and the main outfall station (12) is presented in table 11. The stations are identified in table 8 and located in figure 3.

Storm runoff in area B is discharged to the Holston River through seven channels or west to Arnott Branch through three channels. Most cooling waters, the building drains, and washdown waters are carried by a sewer to natural drainages.

The industrial wastes produced in area A include (1) residues from the concentration of acetic acid, (2) acetic acid from spill and leaks, (3) phenol and residual tar from the producer gas plant, (4) fly ash and boiler blowdown, (5) water treatment brines and sludges, and (6) large quantities of cooling waters. Waste loading from specific sources was determined in a survey by USAEHA. Those results have been incorporated into table 20. Plans for segregation and treatment of the cooling waters and industrial wastewaters are discussed in section IV, H. "Construction and Modernization." Building 2 wastewaters are currently treated in an aerated lagoon (figure 5), which discharges 0.1 to 0.14 Mgal/d.[2]

The main activities at area B include production and concentration of nitric acid; production of ammonium nitrate; production, purification, and packaging of explosives; and the recovery of dilute acetic acid.

Nitric acid is produced by the oxidation of anhydrous ammonia to nitrogen oxide, which is dissolved in water to produce dilute nitric acid (buildings 302 and 302-B, ammonia oxidation process units). It is concentrated to 99% by extractive distillation with magnesium

Table 20. Water Emissions from Area A Sources, Holston Army Ammunition Plant

Description	Flow		Waste characteristics	Monitoring station
	Estimated	Measured		
	Mgal/d			
Building 2 (acetic acid concentration)				
Cooling waters (producer acid cooler, azeo and vent condensers, and flash column condenser)	6.62	26.5	River water	A02E
Flash column effluent	0.003	0.024	Nitromethane, methyl nitrate, distillate water, acetic acid, n-propyl acetate, trace explosives, nitric acid	A02R*
Sludge-heater sludge	0.008	0.008	Carbonaceous charcoal, polymers, trace acetic acid, high color, solids	A02R*
Buildings 7 and 20 (acetic anhydride manufacture)				
Cooling waters (scrubber, barometric and furnace condensers)	0.45	2.8	River water	A02Q
Water scrubber discharge	0.001	0.012	Filtered water, acetic anhydride, acetic acid, low boiling compounds.	A02Q
Building 6 (acetic anhydride refining)				
Cooling waters (acid and anhydride product condenser)	1.9	7.5	River water	A020
Ball mill	0.072		Sludge containing carbon polymers, acetic anhydride	A020
Building 6 (acetic acid concentration)				
Cooling waters (azeo, flash column, pure product and low boiler condensers)	7.6		River water	A020
Flash column effluent	0.0003		Acetone, ethylacetate acetonitrile, methyl cyanide	A020
Sludge-heater sludge	0.008		Carbon, ammonium, phosphate, acetamide, polymers, low pH, solids ≅ 1%, high color	A020
Building 10 (producer gas plant)				
Cooling water	0.18	0.32	River water	A02P

*MCA project 72, line item 6, phase 1.

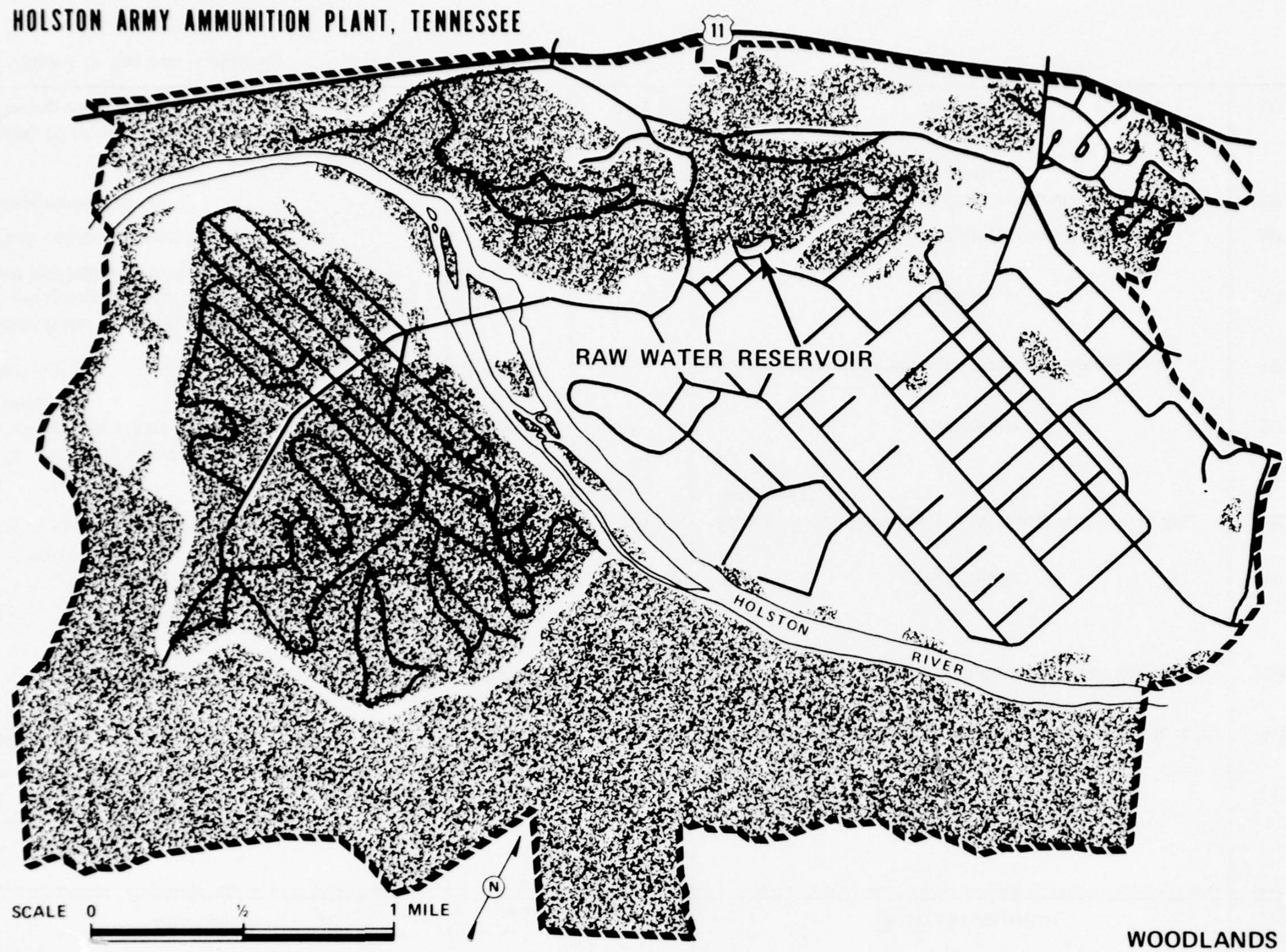


Figure 7. Distribution of Woodlands at Area B

nitrate (nitric acid concentration, building 334, currently active). The process wastewaters from these operations include ammonia, nitric acid, the nitrate ion, and a small amount of oil from the compressors used in the ammonia oxidation process. The process wastewaters and cooling waters are discharged into Arnott Branch.

The concentrated nitric acid and anhydrous ammonia are used to prepare the nitric acid-ammonium nitrate solution (building 330). Essentially all of the waste flow is cooling water, which is discharged into Arnott Branch. Before the nitration step, hexamine is dissolved in glacial acetic acid (C building). The ammonium nitrate-nitric acid solution is stored for use elsewhere, and lacquer mixtures (C buildings) for use in the G buildings are also prepared. Waste flow from these processes include spilled hexamine and small amounts of acids and other organics. These are measured as COD and nitrogen compounds.

The hexamine-acetic acid solution is pumped to the nitration area (D buildings) where the hexamine solution is batch nitrated with the nitric acid-ammonium nitrate solution to produce crude RDX ($C_3H_6O_6N_6$) or crude HMX ($C_4H_8O_8N_8$). Contaminated wastewaters from the nitration operation are routed through a catch basin en route to an industrial sewer. The wastewaters from this operation include cooling water, condensate, agitator seal water, and floor and equipment washdown water. The contaminants include RDX, HMX, acetic acid, and other materials from leaks and spills.

The explosive slurry is then filtered, washed, and reslurried in the E buildings for further processing. The contaminated wastes include explosives, acetic acid, nitric acid, and other components of the mixture which pass through a baffled catch basin before entering an industrial sewer.

The explosives are then dewatered and recrystalized in the G buildings using toluene, acetone, or cyclohexanone, depending on the type of crystal desired in the explosive. The wastewaters (mostly cooling water, seal water, and condensate) are passed through baffled catch basins before entering the storm sewers. The contaminants include solvents, explosives, lacquers, and other compounding agents.

The dewatered explosive is then ground in a water slurry in some of the H buildings. The explosives are then settled out of the slurry. The overflow water drains to a catch basin and then to the sewer. The wastewater contains explosives, solvents condensate, acetic acid, settling tank overflow, and wash water.

The final product is formed by mixing dried RDX or HMX with melted TNT in the incorporation buildings (I, J, L, and M). The air used in drying in line 1 and some special product lines is scrubbed once with water before it is discharged to the atmosphere. The contaminated cooling waters are discharged into the Holston River.

Explosives are received in barrels or nutsches at the N building and are packaged for shipment. Dust is exhausted from the buildings and scrubbed with water. The scrubber water and washwater enter a catch basin and are discharged to the Holston River.

Spent acetic acid is recovered and returned to area A for refining. Sludges from this process were sent to the fertilizer facility (building T-1) prior to a fire in 1973. Two holding ponds were then constructed to contain these sludges which are now being processed in building T-2. Waste streams containing acetic acid, methyl amine, dimethylamine, and some ammonia empty into Arnott Branch. The concentration of the wastes in the discharge generally complies with existing stream standards. However, the current total waste loading will not

comply with HAAP's 1977 permit requirements (table 9). The high levels of nitrogen (ammonia, nitrate, and Kjeldahl); phosphate; solids; and organic carbon associated with area B wastewaters create high chemical and biochemical oxygen demands. In addition, waste acids from spills, leaks, and direct discharge cause a nitrogen problem in Arnott Branch. Although a detailed survey of HAAP discharge rates and pollutant concentrations was made in 1971, most of the data were rough estimates. Since that survey, some modernization has been implemented and production levels have declined from 70% of mobility in 1971 to less than 20% currently. Furthermore, because the pattern of the discharges is different for various production lines, water emissions were not tabulated. For detailed information, the reader is directed to the water quality section and referenced reports.

3. Litigation.

A formal complaint against Holston Defense Corporation was filed by Dr. Eugene W. Fowinkle, Director, Tennessee Department of Public Health, on 21 May 1973 for an alleged illegal discharge of pollutants into the South Fork of the Holston River from area A and the Holston River from area B. As a result of that complaint, an agreement was made between the Tennessee Division of Water Quality Control and the US Army which established effluent limitations (table 9) and a compliance schedule for implementing a water pollution abatement program.

The schedule required submission of an engineering report for treatment by 1 February 1974, submission of final plans by 1 May 1975, initiation of construction by 1 July 1975, and completion of construction by 1 July 1977. Holston Army Ammunition Plant has missed all of these dates except, of course, the last one.[41]

Suits against HAAP for violations of Tennessee air pollution regulations had not been filed until the question of regulatory jurisdiction was resolved by the US Supreme Court.[42] This 7 June 1976 ruling in favor of autonomy by the Federal Government will probably be accepted by Tennessee. Therefore, EPA Region IV will file any further actions against HAAP. The EPA is currently satisfied with the progress of pollution abatement of HAAP and no further litigation is expected.

E. Storage.

Ammunition is stored in X and Y magazine areas (figure 4). The classification yard consists of earth barriers behind which trailers loaded with explosives can park temporarily. The explosives are later moved to the X and Y magazine areas. Toxic and hazardous materials stored at Holston Army Ammunition Plant are shown in table 21.[39] These materials are used or produced during the manufacturing process. Coal piled near the steam plants at areas A and B is not covered, and the storage area is not diked. Figures 5 and 6 show the locations of these coal piles.

F. Pest Control Measures.

Pesticides and herbicides are used extensively to control insects and weeds in almost all parts of Holston Army Ammunition Plant (table 22). Monocultured plantings are more susceptible to damage by insects and pathogenic organisms than is the surrounding vegetation.

In the summer of 1973, after 2 years of damage, some shortleaf and loblolly pine plantings were sprayed with a 6% malathion mist to check the spread of the virginia pine sawfly. Southern pine beetles have been found in small numbers later, but now have spread to the pine trees weakened by the sawfly. No control has been attempted as of July 1975. Further damage

Table 21. Toxic and Hazardous Materials Stored at Holston Army Ammunition Plant

Nitric acid-ammonium nitrate solution	Propyl alcohol
Nitric acid, strong	Acetone
Nitric acid, weak	Cyclohexanone
Sulfuric acid	Stearic acid
Aqueous ammonia	Acetic acid, crude
Anhydrous ammonia	Acetic acid, strong
Caustic soda (sodium hydroxide)	Acetic acid, weak
Quick lime (solid)	Hexamine-acetic acid solution
Chlorine (gas)	Butyl acetate
Fly ash	Di-octyl adipate
Ammonium nitrate - solid	Di-octyl phthalate
Aluminum sulfate - dry (solid)	Ethyl acetate
Aluminum sulfate - liquid	Isobutyl acetate
Calcium silicate - solid	Laminac
Disodium phosphate - solid	Propyl acetate
Magnesium nitrate	Sodium stearate
Magnesium oxide - solid	Tar, gas producer and steam plant, area A
Rock salt - solid	Toluene
Sodium sulfites - solid	Benzene
Triethyl phosphate - solid	Pentachlorophenol
Sodium nitrate - solution and solid	Diphenylamine
Asphalt desensitizing wax	Hexamine - dry bulk
Fuel oil No. 2	HMX
Fuel oil No. 6	Nitrocellulose
Gasoline	RDX
Hydraulic oil	TNT
Lubricating oil	DMSO (dimethyl sulfoxide)
Unprocessed oil (waste oil)	Acetic anhydride, refined
Butyl alcohol	Acetic anhydride, crude
Methanol	

Table 22. Types of Herbicides and Pesticides Used at Holston Army Ammunition Plant*

Herbicides	Purpose	Quantity used, CY74	Area used
2,4-D	Broad-leafed weeds	300 gal	Rights-of-way, firebreaks, parking lots, drainage ditches, magazine area, production area, and administrative area
2,4,5-T	Broad-leafed weeks	300 gal	
Dalapon (Dowpon)	Soil sterilant	1,000 lb	
Maintain CF-125		20 gal	
Pramitol	Soil sterilant	10,000 lb	
Bromacil		2,800 gal	
Ammate	Soil sterilant	6,000 lb	
Silvisar		45 gal	

Pesticides	Purpose	Projected usage for CY76	Area used
Ammate-X	Herbicide	7,500 lb	As above
Amine 2,4-D	Herbicide	55 gal	As above
Dalapon	Herbicide	300 lb	As above
Hyvar X-L	Herbicide	300 lb	As above
MSMA	Herbicide	300 lb	As above
Karmex	Herbicide	60 lb	As above
Maintain CF-125	Herbicide	10 gal	As above
Pramitol	Herbicide	6,000 lb	As above
Silvisar 510	Herbicide	10 gal	As above
Tordon 10-K	Herbicide	900 lb	As above
Weedone 2,4,5-T	Herbicide	160 gal	As above
Chlordane	Control ants	55 gal	Around buildings
Diazinon	Control blackflies	17 gal	Drainage ditches
6-12	Repell insects	75 cans	Production area
Malathion, 57%	Control forest pests	115 gal	Forest, production, and administrative areas
Malathion, 95%	Control forest pests, blackflies	115 gal	Forest areas, drainage ditches
Soluble malathion and pyrethron concentrated aerosol	Control flying insects	140 cans	In buildings
Rodenticide (anticoagulant)	Control rats and mice	30 lb	In buildings
D-Con	Control roaches	20 lb	Administrative area
Diaphacin (paraffin blocks)		50 ea	
Wasp stopper (14-oz aerosol cans)		175 cans	Administrative area and production building

*Sources: Joseph Lady, Fish and Wildlife Plan for HAAP, revised July 1975.
Joseph Lady, Land Management Plan for HAAP, revised April 1974.

to loblolly pines and black locust is being minimized by eliminating them from the planting program. Cottonwoods were introduced to HAAP (and eastern Tennessee) by a planting program. In 1975, the planting was damaged by cottonwood beetles and Japanese beetles: the damage was controlled by insecticides.[19] Insecticides and rodenticides are also used to rid buildings of pests. Malathion is sprayed in an ultra-low-volume mist to kill blackflies which spawn in drainage ditches on the ammunition plant (Joseph Lady, Supervisor, Storage and Maintenance, HDC, personal communication).

In March 1976, biologists from USAEHA at Fort Meade, Maryland, investigated the effects of short-term treatment of the cooling water streams at HAAP with diazinon to kill blackfly larvae (Mr. Carl Neidhardt, USAEHA, Fort Meade, Maryland, personnal communication). Although their report is not completed, a low-volume, short-term dosing method may be useful for blackfly control.

Herbicides are generally used to keep parking lots, walkways, building foundations, and storage areas free of weeds.[28] Soil sterilants were used heavily in the late 1960's for this purpose: they were injected under pressure through a spray bar with jets placed approximately 2 feet into the ground. The production areas are now covered with gravel to discourage weed growth, and soil sterilants are used for spot treatment.

G. Resource Management Programs.

1. Forest Management.

The 5-year Forest Management Plan provides for the development of HAAP's woodlands.[19]

There are 3,828 acres of woodland under management.[8] Figure 7 indicates the wooded areas. Most of this area was used for agriculture, and all wooded areas were cut over approximately 75 years ago.

Since 1968, 819 acres of suitable land have been reforested with southern yellow pines (shortleaf and lobbolly) and eastern white pine. A 5-year program has been proposed to establish approximately 20 acres per year of walnut and cottonwood plantations in the west central part of the bottom land along the north bank of the Holston River.

Management practices encourage the growth of certain tree species because of their reliable market value and ability to produce maximum amounts of usable forest products. These species are listed in appendix B.

The harvesting program is such that undesirable trees are removed during early cutting cycles to supply logs, rough lumber, and pulpwood. Eventually, the more desirable species will constitute a larger percentage of natural stands that can be used for veneer logs, high-grade lumber, and locust poles and posts.

Woodlands on the installation are divided into compartments and cutting units. Various compartments or units are scheduled to be selectively harvested annually.[19] Vines, such as honeysuckle and kudzu, cause considerable damage to the trees in the plantations and are controlled by spraying the herbicides 2,4-D and Maintain CF-125. Large undesirable trees, if left uncut, are killed by use of the Hypo Hatchet,* which girdles the trees. These trees may be potential reservoirs for diseases and insect damage.

*TSI Company, Flanders, New Jersey.

Specific rights-of-way are not cleared as firebreaks: roads and fences running through wooded areas provide fire protection.

2. Fish and Wildlife Management.

The Fish and Wildlife Management Plan coincides with a cooperative agreement between HAAP, the Bureau of Sport Fisheries and Wildlife, Department of Interior, and the Tennessee Wildlife Resources Agency.[43]

Common game birds on the installation include the bobwhite, mourning dove, black duck, mallard, and wood duck. The principal game mammals are the cottontail, the gray squirrel, the raccoon, and a few whitetail deer.

Several stocking programs have been conducted on the installation. A 3.16-acre raw water reservoir shown in figure 7 was stocked with largemouth bass and bluegills in 1966. However, most of these fish were killed in 1967 by the high oxygen demand of the Holston River water which is pumped into the reservoir. In 1972, the reservoir was treated with Fintrol to determine its fish inhabitants. A total of 140,546 fish was collected. Restocking was conducted with 5,000 fingerling channel catfish. The whitetail deer and turkey population existing on the installation is the result of stocking projects. Seven deer have been released on the installation, and several more immigrated from Bays Mountain State Park after a similar stocking program there. Twenty adult turkeys have been placed on the installation. Since these programs have just begun, the long-range results are not known. However, it is anticipated that the protection offered by the installation will enhance the establishment of these populations.

Predator control includes either destroying foxes, feral dogs, and skunks or live-trapping these animals and removing them from the installation. These activities are conducted when it is judged that the animals constitute a hazard to the safety and well-being of the installation personnel.

The planting of corn, soybeans, milo, wheat, buckwheat, and millet provides food and cover for waterfowl and upland game birds. The 1976 annual work plan for fish and wildlife management includes the planting of 180 acres of annual grains and 5 acres of perennial plants.

In 1955, the Holston Gun Club was organized to control the hunting at HAAP. Hunting privileges were rescinded in 1959 for plant safety. Small game hunting was again permitted from 1965 to 1975, at which time it was stopped. Excessive traffic from hunters may threaten or damage the habitats which contain several endangered species of plants (see "Flora" section) and provide potential nesting sites for two endangered bird species: the grasshopper sparrow, *Ammódramus savannárum*, and Bachman's warbler, *Vermivora bachmanii* (see "Fauna" section). On the other hand, hunting provides the most practicable method to control overpopulation of deer; however, because there is abundant food and habitat in the vicinity of HAAP, hunting is probably not needed at the this time. Therefore, it is recommended that the hunting restrictions should continue at HAAP until the status and location of various plants and animals can be determined from a field survey. Fishing is permitted in the raw water reservoir.

3. Land Management.

Of the 6,025 acres of land on the installation, 33 acres are improved grounds, 1,086 acres are semi-improved grounds, and 1,111 acres are unimproved grounds.* The remaining land is forested.

*Figures taken from Land Management Plan.[8]

Maintenance performed on the improved land consists of mowing and occasional reseeding and fertilizing, not to mention the lawns and athletic field which are mowed three times a month during 3 to 5 months of the year. The only landscaping that has been done is the planting of a few shrubs near administrative buildings. The semi-improved area includes the magazine storage area and road shoulders, which are mowed twice a year, and fertilized and reseeded as required, and wildlife food plots which are seeded for wildlife management. The unimproved grounds, such as agricultural leases, ponds and streams, pavement and railroads, and buildings, are not maintained under the land management plan. Improved and semi-improved grounds are fertilized with commercial 5-10-10 fertilizer with additional ammonium nitrate.

Herbicides and mowing are used to control weeds and brush. Weed-killing chemicals in use are 2,4-D, 2,4,5-T, Hyvar X-L, Pramitol, Ammate-X, Maintain CF-125, Tordon 10-K, Dowpon, and Silvisar 510. For fire prevention around explosives-production buildings, soil sterilants and crushed rocks are used to eliminate vegetation.

Erosion is controlled by seeding and fertilizing areas where vegetation has been disturbed. Rye grass, fescue, and bermuda grass are commonly used for steep slopes and other areas prone to erosion. Calcium chloride and water are used to control dust on dirt roads and in construction areas.

H. Construction and Modernization.

Table 23 lists all of the construction and modernization projects at HAAP. MCA project line items 3 and 15 and PAA project 570-2072 are primarily for the reduction of NO_x; MCA project line items 2, 4, 19, and 20 are for the reduction of particulate emissions.[39] These projects should reduce these emissions to within the Tennessee State air pollution standards. MCA project line items 1, 6, 10, 12, 13, 14, 16, and 18 are water-pollution projects to treat and eliminate the discharge of wastewaters detrimental to the quality of the Holston River. Present plans call for pumping all waters to area B for treatment. PAA project line items 23 and 24 are to increase awareness of plant air- and water-pollution facilities preventive actions. The remaining PAA projects are for the modernization of the manufacturing area to increase the production efficiency.[40]

Problems of air pollution will be solved by the construction of new facilities and the installation of pollution-abatement equipment. Electrostatic precipitators will be installed in each of the 10 spreader stoker boilers in buildings 8 and 200. There are no modifications planned for building 222, which is currently inactive.

Molecular sieves will be added to supplement the absorption columns on the nitric acid concentration units, and sieves will also be installed on four old ammonia oxidation process units (MCA 72 line item 3). Two incinerators will be constructed, one 2-tons-per-day capacity unit for explosive wastes, and one 11-tons-per-day unit for explosive contaminated wastes.

Phase 1, line item 1 (wastewater treatment), segregated the industrial wastes and cooling waters from the acid concentration area (building 2, area A) and provided treatment for the industrial waste. Cooling waters are now discharged to the industrial and storm sewer (figure 5). Phase 2 will segregate the remaining cooling water and industrial wastes in area A. The wastes will be collected in a central industrial sewer for treatment in the wastewater treatment facility at area B. Dikes were constructed around the production area to insure that no industrial wastes from spills and leaks enter the surface runoff or cooling water streams.

Table 23. Construction and Modernization Projects at Holston Army Ammunition Plant Which Potentially Affect the Quality of the Environment

Project number	Funding (FY)	Estimated completion (FY)	Project description
MCA LI 1	70	73	Area A pollution control pond (phase I) pilot has been operating since 15 March 1973.
MCA LI 2	72	74	Three precipitators and smoke detectors, one in building 8, area A, and two in building 200, area B, reduce pulverized coal-fired boiler stack particulate emissions.
MCA LI 3	72	78	Abatement of air pollution (NO_X) at four DuPont ammonia oxidation process units, area B, building 200 - molecular sieve.
MCA LI 15	72	78	Abatement of air pollution (NO_X) at nine nitric acid concentration units, area B, buildings 503, 334, 304, and 303-B - molecular sieve.
MCA LI 4	72	74	Noncontaminated refuse incinerator, reduction of particulate emissions.
MCA LI 6	72	77	Phase I - utility water-pollution abatement - boiler blowdown, filter plant sludge, pumphouse debris disposal.
MCA LI 10	72	74	Tank dikes, areas A and B - contain possible spills.
MCA LI 12, 13, 14	72	78	Industrial wastewater treatment plant, phase I, area B.
MCA LI 18	73	77	Ash water disposal, building 8, area A.
MCA LI 19	73	78	Electrostatic precipitators for 10 stoker-fired boilers, six at area A.
MCA LI 20	74	76	Explosive waste and explosives-contaminated waste incinerator.
MCA LI 21	73	78	Methyl nitrate removal, building 2, area A
MCA LI 23	73	77	Water-pollution monitoring system, areas A and B.
MCA LI 24	73	77	Air-pollution monitoring system.
MCA LI 27	77	-	Industrial wastewater treatment plant, phase II.
PEMA 570-2072	70	76	300-Tons-per-day ammonia oxidation plant.
PEMA 570-2068	70	73	Sodium nitrate facility.
PEMA 571-2034	71	-	Phase II (construction), anhydride modernized plant.
PEMA P-16	71	74	HMX recovery prototype.
PEMA 570-2071	72	-	New buildings to replace C1, C5, and C9.
PEMA 573-2076	73	-	A central lacquer preparation building - replaces operations at C-3, G.

In area B, all separate industrial waste outfalls will be eliminated and all industrial wastes will be treated at a central facility located northwest of the sewage treatment plant. Dikes were also constructed in area B to collect industrial wastes for treatment.

Clark, Dietz, and Associates has received the architect and engineering contract for design of the industrial wastes treatment facility at HAAP.[44] Details are not yet completed, although carbon adsorption and expensive pretreatments for explosive and ammonia wastes will probably be employed. Final design is contingent upon the results of pilot studies recently conducted at HAAP.

V. SUMMARY AND RECOMMENDED ECOLOGICAL SURVEY PLAN.

Holston Army Ammunition Plant is located in a mountainous area which has intense industrial development. Currently industrial wastewater discharges from area A containing organic acids, solvents, and thermal loads are causing deterioration in the South Fork of the Holston River. Arnott Branch is also degraded by discharges of cooling waters and spilled acid from the nitric acid-ammonium nitrate solution building in area B. Surface and industrial sewer drainages from the manufacturing area cause a high waste loading in the Holston River. The water quality of the Holston River and its branches is also degraded by industrial discharges from six other major industries in Kingsport, Tennessee. The regulation of flow in the South Fork of the Holston River and the low dissolved oxygen content of water released from Fort Patrick Henry Dam are also detrimental to assimilation of the wastewaters that are discharged downstream.

HAAP has scheduled an ongoing modernization project that will enhance the quality of its discharges; however, a technology has not yet been demonstrated to treat the explosives-contaminated wastewaters.

The frequency of temperature inversions and the restriction of air movement by the mountains surrounding Kingsport cause the air emissions to concentrate within the Holston River Valley. Some vegetation damage and noxious odors have been reported from neighboring communities, and signs of damage caused by air pollution are evident in the pine trees and other vegetation downwind of the acid facility in area B. The installation of new abatement systems, incinerators, and an air quality monitoring program are expected to eliminate air pollution problems caused by HAAP. Studies of the vegetation sensitive to air pollution would be beneficial to evaluate improvements in air quality.

Underground caverns are associated with several soils found on HAAP. The occurrence of such soils, which subside without warning, limits the areas available for expansion of the manufacturing, support, and disposal facilities at HAAP. As a precaution, the geology of the proposed sanitary landfill site, apparently located in a sinkhole area, should be investigated with special emphasis on the potential for subsidence and groundwater contamination. Likewise, current and future development sites should be examined.

The steep slopes of the southeastern part of HAAP are easily eroded by disturbance or activity that would remove the vegetation. Besides the possibilities for erosion, this natural area potentially contains several plant species which are considered by State and Federal authorities to be rare, endangered, or threatened. Such natural areas should be protected from human disturbance (e.g., hunting); however, cooperative scientific research should be continued with organizations like East Tennessee State University and the Wildflower Club of Kingsport.

Generally, sufficient baseline data exist for the aquatic communities to establish the current impacts of HAAP activities on the environment. An understanding of the impacts of HAAP on the terrestrial environment could be enhanced by additional plant and wildlife inventories. The results of these inventories would be essential to establish management strategies that provide protection of habitats and enhance the environmental characteristics necessary for the survival of species which are under Federal and State protection. After studies by the Surgeon General have been completed and pollution-abatement systems are operating, an aquatic survey should be conducted for comparison.

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APPENDIX A

PLANTS OF HAAP AS IDENTIFIED BY THE WILDFLOWER CLUB OF KINGSPORT, TENNESSEE

Genus/species	Common name
Achillea millefolium	Yarrow
Aesculus octandra	Sweet buckeye
*Agriminia sp.**	Harvest lice
Agrimonia rostellata	Agrimony
Allium sp.	Wild onions
Ambrosia sp.	Ragweeds
*Anemone quinquefolia**	Wood anemone
*Anemonella thalictroides**	Rue-anemone
Aquilegia canadensis	Columbine
Arctostaphylos uva-ursi	Bearberry
Aristolochia durior	Dutchman's-pipe
*Asarum canadense**	Wild ginger
Asclepias quadrifolia	Four-leaved milkweed
*Aster sp.**	Aster
Bidens sp.	Spanish needles, beggarticks
Blephilia ciliata	Downy woodmint
*Brassica sp.**	Mustard
Castilleja coccinea	Painted-cup, Indian paintbrush
Ceanothus americanus	New Jersey tea
Centaurea cyanus	Bachelor's-button
Chamaelirium luteum	Blazing-star
Chenopodium album	Pigweed
Chrysanthemum leucanthemum	Ox-eye daisy
Cicuta bulbifera	Water hemlock
Cimicifuga racemosa	Bugbane
Clintonia borealis	Corn-lily
Cnicus benedictus	Blessed thistle
Comandra umbellata	Bastard-toadflax
Conium maculatum	Poison hemlock
Conopholis americana	Sqawroot
Convolvulus sp.	Bindweed
C. sepium	Hedge bindweed
Coreopsis lanceolata	Lance-leaved Coreopsis
*C. major**	Tickweed
Crepis capillaris	Hawksbeard
*Cypripedium acaule***	Lady's-slipper (Sharp, USDA)
C. calceolus#	Yellow lady's-slipper
Datura stramonium	Jimsonweed
Delphinium sp.	Larkspur
Desmodium sp.	Tick-trefoil
D. canescens	Hoary tick-trefoil
D. nudiflorum	Naked-flowered trefoil
Dicentra cucullaria	Dutchman's-breeches

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Dipsacus laciniatus	Teasel
*Disporum maculatum***	Nodding mandarin (Sharp)
Dodecatheon meadia	Shooting star
Echinocystis lobata	Wild cucumber
*Epigaea repens**	Trailing-arbutus or Mayflower
Erigeron annuus	Daisy fleabane
*E. pulchellus**	Poor robin's-plantain
*Erythronium americanum**	Trout-lily
Euonymus americanus	Strawberry bush
*Eupatorium fistulosum**	Joe-pye-weed
Euphorbia corollata	Tramps or flowering spurge
E. marginata	Snow-on-the-mountain
Fragaria virginiana	Wild strawberry
Galax aphylla	Galax
Galium sp.	Bedstraw
Gnaphalium obtusifolium	Rabbit tobacco
Gaultheria procumbens	Wintergreen
*Geranium maculatum**	Wild geranium
Glechoma hederacea	Gill-over-the-ground
Gleditsia triacanthos	Honey locust
Helianthus sp.	Sunflower
*Hepatica sp.**	Hepatica
H. americana	Hepatica
*Heuchera villowa**	Alumroot
*Hibiscus palustris**	Marsh mallow
Hieracium paniculatum	Hawkweed
Houstonia caerulea	Bluets
Hypericum sp.	St. Johnswort
H. punctatum	Spotted St. Johnswort
*Hypoxis hirsuta**	Stargrass
Impatiens sp.	Touch-me-not
I. capensis	Spotted Touch-me-not
I. pallida	Pale Touch-me-not
*Impomoea sp.**	Morning-glory
Iris sp.	Iris
I. cristata	Crested dwarf iris
I. versicolor	Large blue flag iris
Kalmia latifolia	Mountain-laurel
*Lactuca floridan**	Blue lettuce
Laportea canadensis	Wood nettle
*Liparis lilifolia***	Large twayblade (USDA)
Lobelia inflata	Indian-tobacco
*Lonicera japonica**	Honeysuckle
Ludwigia polycarpa	Many-fruited false loosestrife
Lysimachia sp.	Loosestrife
L. quadrifolia	Whorled loosestrife
*Maianthemum canadense**	Lily-of-the-valley
Medeola virginiana	Indian cucumber-root

Melothria pendula	Creeping cucumber
Mentha longifolia	Horsemint
Mertensia virginica	Virginia bluebells
Mitchella repens	Partridgeberry
*Mitella diphylla**	Bishop's-cap
Nepeta cataria	Catnip
Onosmodium virginianum	False gromwell
Orchis spectabilis	Showy orchis (Taft)
Oxalis sp.	Sorrel
O. Violacea	Violet wood-sorrel
Oxypolis rigidior	Cowbane
*Panax quinquefolius***	Ginseng (Sharp, USDA)
*P. trifolius**	Dwarf ginseng
Parthenocissus quinquefolia	Virginia-creeper
Penstemon hirsutus	Hairy beardtongue
*Phlox sp.**	Phlox
*Phytolacca americana**	Poke
*Plantago sp.**	Plantain
*Podophyllum peltatum**	Mayapple
Polemonium reptans	Greek-valerian
*Polygonatum biflorum**	Solomon's-seal
*Polygala paucifolia***	Gaywings (Sharp) or fringed polygala
Potentilla sp.	Cinquefoil
P. recta	Rough-fruited cinquefoil
Ranunculus sp.	Buttercup
Ratibida pinnata	Gray-headed coneflower
*Rhamnus carolinana**	Buckthorn
Rhododendron sp.	Azalea
R. calendulaceum	Flame azalea
*Rosa multiflora**	Multiflora rose
*Rubus sp.**	Blackberry
Rumex sp.	Dock
*Sanguinaria canadensis**	Bloodroot
Satureja vulgaris	Basil
*Sedum sp.**	Roseroot
S. ternatum	Stonecrop
Senecio vulgaris	Common groundsel
Sisyrinchium augustifolium	Blue-eyed-grass
*Smilacina racemosa**	False Solomon's-seal
Smilax herbacea	Jacob's-ladder
Solanum carolinense	Horse-nettle
S. dulcamara	Nightshade
Solidago sp.	Goldenrod
*Sonchus oleraccus**	Sow-thistle
*Stellaria sp.**	Chickweed
Streptopus amplexifolius	Twisted stalk
*Symplocarpus foetidus***	Skunk cabbage (Sharp, USDA)
*Taraxacum officinale**	Dandelion

Thalictrum dioicum	Meadowrue
T. polygamum	Meadowrue
*Tiarella cordifolia**	Foamflower
Tilia americana	Basswood
*Trifolium sp.**	Clover
T. pratense	Red clover
T. repens	White clover
*Trillium sp.**	Trillium
*Typha latifolia**	Broad-leaved cattail
Uvularia sp.	Bellwort
U. grandiflora	Large-flowered bellwort
U. perfoliata	Perfoliate bellwort
*Verbascum sp.**	Mullein
Vernonia noveboracensis	Ironweed
*Viola sp.**	Violet
V. canadensis	Violet
V. cucullata	Violet
V. emarginata	Violet
V. hastata	Violet
V. pedata	Violet
Vitus aestivalis	Summer grape
V. vulpina	Frost grape
Yucca filamentosa	Beargrass or Adam's needle
Zizia trifoliata	Meadow-parsnip

*Observed during field trip, 4 April 1976.
** Considered rare, endangered, or threatened by authorities within ( ).
# Identified as rare by Mr. Joe Taft, Naturalist, Bays Mountain Park, 4 April 1976.

APPENDIX B

SURVEY OF THE PLANTS AND FERNS ON BAYS MOUNTAIN AND HOLSTON ARMY AMMUNITION PLANT, KINGSPORT, TENNESSEE

Genus/species	Common name
*Acer negundo#**	Boxelder
A. nigrum	Black maple
A. pensylvanicum	Striped maple
*A. rubrum#**	Red maple
A. rubrum var. trilobum	Carolina red maple
A. saccharinum	Silver maple
*A. saccharum#**	Sugar maple
Albizzia julibrissin	Mimosa
Aletris farinosa	Colicroot
Alisma subcordatum	Water plantain
*Ambrosia trifida***	Great ragweed
Amelanchier arborea#	Shadbush
Amianthium muscaetoxicum	Fly-poison
Amphicarpa bracteata	Hog-peanut
Andropogon virginicus	Broom sedge
Anemone virginiana	Thimbleweed
Antennaria plantaginifolia	Plantain-leaved everlasting
Apios americana	Ground nut
Apocynum androsaemifolium	Dogbane
Aralia racemosa	Spikenard
Arisaema atrorubens	Jack-in-the-pulpit
Asarum virginicum	Heartleaf
Asclepias amplexicaulis	Clasping-leaved milkweed
A. exaltata	Poke milkweed
A. incarnata	Swamp milkweed
A. syriaca	Common milkweed
A. tuberosa	Butterflyweed
A. variegata	Variegated milkweed
A. verticillata	Whorled milkweed
Ascyrum hypericoides	St. Andrew's Cross
*Asimina triloba#**	Pawpaw
Astilbe biternata	False goatsbeard
Barbarea vulgaris	Winter cress
Bartonia paniculata	Screwstem
Benzoin aestivale	Spice bush
Betula lenta	Sweet birch
B. nigra	River birch
Bignonia capreolata	Cross vine
Boehmeria cylindrica	False nettle
Campanula divaricata	Southern harebell
Campsis radicans	Trumpet-creeper
Carex hystricina	Porcupine sedge
C. intumescens##	Bladder sedge

C. rostrata	Bottle-shaped sedge
C. scabrata	Rough sedge
Carya cordiformis	Butternut hickory
C. glabra	Pignut hickory
C. laciniosa	Shellbark hickory
*C. ovata#**	Shagbark hickory
C. ovata var. pubescens##	Pubescent shagbark hickory
C. pallida##	Pale hickory
C. tomentosa##	Mockernut hickory
Cassia fasciculata	Partridge-pea
C. marilandica	Wild senna
Castenea dentata#	Chestnut
C. pumila#	Chinquapin
Catalpa speciosa	Western catalpa
Celtis laevigata	Hackberry
*C. occidentalis#**	Hackberry
Cephalanthus occidentalis	Buttonbush
Cercis canadensis	Redbud
Chimaphila maculata	Wintergreen
Cichorium intybus	Chicory
Circaea quadrisulcata	Enchanter's nightshade
Clematis virginiana	Virgin's-bower
Collinsonia canadensis	Horse-balm
Commelina communis	Dayflower
Cornus alternifolia#	Alternate-leaf dogwood
*C. florida#**	Flowering dogwood
Corylus americana	American hazelnut
C. cornuta	Beaked hazelnut
*Crataegus sp.#**	Hawthorn
Cypripedium acaule	Lady's-slipper (Sharp, USDA)
Daucus carota	Queen Anne's lace
Dioscorea batatas	Cinnamon vine
D. villosa	Wild yam
*Diospyros virginiana#**	Persimmon
Erigeron canadensis	Horseweed
E. philadelphicus	Fleabane
E. strigosus	Daisy fleabane
*Fagusgrandifolia#**	American beech
F. grandifolia var. caroliniana	Beech
*Fraxinus americana#**	White ash
F. americana var. biltmoreana	Biltmore ash
F. pennsylvanica	Red ash
Galium aparine#	Goosegrass
Gaylussacia baccata	Black huckleberry
Gerardia laevigata	False foxglove
Gillenia trifoliata	Bowman's-root
Gnaphalium obtusifolium	Everlasting

Goodyera pubescens	Downy rattlesnake-plantain
Gymnocladus dioica	Kentucky coffee-tree
Hamamelis virginiana#	Witch hazel
Houstonia purpurea	Large Houstonia
Hybanthus concolor	Green violet
Hydrangea arborescens	Wild hydrangea
Hydrophyllum macrophyllum	Waterleaf
Ilex opaca#	American holly
*Ipomoea pandurata#**	Wild potato-vine
Juglans cinerea#	White walnut
*J. nigra#**	Black walnut
Juncus validus	Rush
*Juniperus virginiana#**	Red cedar
*Kalmia latifolia#**	Mountain laurel
Lathyrus venosus	Veiny pea
Lepidium virginicum	Peppergrass
Lindera benzoin	Spicebush
*Liquidambar styraciflua#**	Sweet gum
*Liriodendron tulipifera#**	Yellow poplar
*Lobelia cardinalis***	Cardinal-flower
L. inflata	Indian-tobacco
L. siphilitica	Great lobelia
Ludwigia alternifolia	Seedbox
L. palustris	Water-purslane
Lyonia ligustrina	Maleberry
Lysimachia tonsa	Shaved loosestrife
*Magnolia acuminata#**	Cucumber tree
Melilotus alba	White sweet clover
Menispermum canadense	Moonseed
Mentha piperita	Peppermint
Mimulus alatus	Sharp-winged monkey-flower
M. ringens	Square-stemmed monkey-flower
Monarda clinopardia	Basal balm
M. fistulosa	Wild bergamot
Monotropa hypopithys	Pinesap
M. uniflora	Indian-pipe
*Morus rubra#**	Red mulberry
*Nyssa sylvatica#**	Black gum
Oenothera biennis	Common primrose
Orobanche uniflora	One-flowered cancer-root
Osmorhiza claytoni	Sweet Cicely
*Ostrya virginiana#**	Hop hornbeam
Oxalis europaea	European wood-sorrel
O. grandis	Large wood-sorrel
*Oxydendrum arboreum#**	Sourwood
Passiflora lutea	Yellow passion flower
Paulownia tomentosa	Princess-tree
Pedicularis canadensis	Lousewort

Penthorum sedoides	Ditch stonecrop
Phoradendron flavescens	Mistletoe
Physocarpus opulifolius	Ninebark
*Phytolacca americana***	Poke
*Pinus echinata#**	Shortleaf pine
P. resinosa	Red pine
*P. rigida#**	Pitch pine
P. strobus##	White pine
P. taeda##	Loblolly pine
*P. virginiana#**	Scrub pine
*Plantago lanceolata***	English plantain
*P. major***	Common plantain
Platanus occidentalis#	Sycamore
Polygonum persicaria	Lady's-thumb
P. sagittatum	Arrow-leaved tearthumb
Polymnia canadensis	Leafcup
P. uvedalia	Large-flowered leafcup
Populus deltoides	Cottonwood
Prunus americana	Wild plum
P. persica	Peach
*P. serotina#**	Wild black cherry
Pycnanthemum sp.	Mountain-mint
Pyrularia pubera	Oilnut
Pyrus arbutifolia	Red chokecherry
P. communis	Pear
P. melanocarpa	Black chokecherry
*Quercus alba#**	White oak
Q. borealis maxima	Northern red oak
*Q. coccinea#**	Scarlet oak
*Q. falcata#**	Spanish oak
Q. marilandica#	Blackjack oak
Q. muehlenbergii##	Chinquapin
Q. palustris	Pin oak
Q. prinus#	Chestnut oak
Q. rubra	Southern red oak
Q. stellata	Post oak
*Q. velutina#**	Black oak
*Rhamnus caroliniana#**	Carolina buckthorn
Rhexia mariana	Deergrass or meadow-beauty
*Rhododendron catawbiensis#**	Catawba rhododendron
*R. maximum#**	Great rhododendron
R. nudiflorum	Pinxter-flower
R. roseum	Early azalea
Rhus aromatica##	Fragrant sumac
R. copallina#	Winged sumac
R. glabra#	Smooth sumac
R. radicans##	Poison-ivy
R. typhina	Staghorn sumac

Robinia pseudo-acacia	Black locust
R. vicosa	Clammy locust
Rosa carolina	Carolina rose
R. palustris	Swamp rose
R. setigera	Prairie rose
*Rubus allegheniensis***	Blackberry
*R. occidentalis***	Raspberry
*R. odoratus***	Raspberry
*R. phoenicolasius***	Wineberry
Rudbeckia hirta	Black-eyed susan
Ruellia humilis	Low ruellia
Sabatia angularis	Rose-pink
Salix alba##	White willow
S. babylonica	Babylonian weeping willow
S. humilis	Tall prairie willow
S. interior	Sandbar willow
S. nigra#*	Black willow
Salvia lyrata	Lyre-leaved sage
Sambucus canadensis	Common elderberry
Sassafras albidum#*	Sassafras
Saururus cernuus	Lizard's-tail
Silene stellata	Starry campion
S. virginica	Fire pink
Silphium perfoliatum	Cup-plant
Smilax glauca##	Glaucoma greenbrier
S. rotundifolia##	Common greenbrier
*Solidago rugosa***	Goldenrod
Sparganium americanum	Bur-reed
Specularia perfoliata	Venus' looking-glass
Stachys riddellii	Hedge-nettle
Stylophorum diphyllum	Wood-poppy
*Taraxacum officinale***	Dandelion
Tilia heterophylla	White basswood
T. neglecta	Basswood
Tipularia discolor	Cranefly orchis
Tovara virginiana	Knotweed
Tradescantia subaspera	Spiderwort
T. virginiana	Virginia spiderwort
Trillium erectum	Purple trillium
Tsuga canadensis#*	Eastern hemlock
Ulmus alata#*	Winged elm
U. americana#*	American elm
U. rubra#*	Slippery elm
U. thomasi	Rock elm
Vaccinium stamineum	Deerberry
V. vacillans	Blueberry
Verbascum blattaria	Moth mullein
*V. thapsus***	Common mullein

Verbena hastata	Blue vervain
V. urticifolia	White vervain
Verbesina occidentalis	Crownbeard
Viburnum acerifolium	Mapleleaved viburnum
V. nudum	Southern-wild-raisin
V. prunifolium	Blackhaw
Vicia dasycarpa	Vetch
Vitis aestivalis var. argentifolia	Silverleaf grape

Ferns:

Adiantum pedatum#	Maiden hair fern
*Asplenium platyneuron**	Ebony spleenwort
Athyrium filix-femina#	Lady fern
A. pycnocarpon#	Glade fern
A. thelypterioides#	Silvery spleenwort
Botrychium virginianum#	Rattlesnake fern
Camptosorus rhizophyllus#	Walking fern
Cystopteris bulbifera#	Bulblet fern
Dennstaedtia punctilobula#	Hayscented fern
Dryopteris hexagonoptera	Board beech fern
D. marginalis#	Evergreen wood fern
D. noveboraconsis	New York fern
D. spinulosa#	Spinulose wood fern
Lycopodium complanatum	Trailing evergreen
Lygodium palmatum#	Hartford fern
Onoclea sensibilis#	Sensitive fern
Ophioglossum, vulgatum, var. pyconostichum	Adder's tongue fern
Osmunda cinnamomea#	Cinnamon fern
O. claytoniana#	Interrupted fern
O. regalis#	Royal fern
Polypodium polypodioides, var. michauxianum	Resurrection fern
P. virginianum#	Common polypody
Polystichum acrostichoides#	Christmas fern
Pteridium aquilinum#	Bracken fern
Woodsia obtusa#	Blunt-lobed woodsia
Woodwardia areolata	Netted chain fern
Thelypteris hexagonaptera	Broad beech fern
T. noveboracensis	New York fern

#Species identified in the Bays Mountain Park, Kingsport, Tennessee.
#*Species identified in the Bays Mountain Park and HAAP, Kingsport, Tennessee.
**Species identified by the Wildflower Club and listed in the Forest Management Plan for HAAP.
##Species listed in the Forest Management Plan for HAAP.

APPENDIX C

DESCRIPTION OF WOODLAND SUITABILITY GROUPS

A woodland suitability group consists of soils that have similar tree growth rates and woodland management problems. Hazards and limitations that are especially important in management for the production of wood crops are described for each suitability group. Tree growth rate is expressed as site index which is the average height of the dominant and codominant trees in well-stocked, unmanaged stands at a given age. Generally a soil will have a higher site index on the lower part of a slope in comparison to the upper part, and northern and eastern exposures of slopes in hilly land compared to southern and western exposures.

The woodland suitability groups (WSG) are described below.

WSG-2o7. Loamy soils with high potential productivity; no serious management problems; suitable for southern hardwoods and pines.

WSG-2w8. Seasonally wet soils with high potential productivity; moderate equipment limitations and slight-to-moderate seedling mortality; suitable for southern hardwoods and/or pines.

WSG-2w9. Excessively wet soils with high potential productivity; severe equipment limitations and moderate-to-severe seedling mortality; suitable for water-tolerant hardwoods or pines.

WSG-3c2. Clayey soils with moderately high productivity; moderate equipment limitations and slight-to-moderate seedling mortality; best suited for southern pines.

WSG-3c8. Cherty soils, low in natural fertility; clay restricts upper level of soils; more than one management problem; suitable for either needleleaf or broadleaf trees.

WSG-3f8. Fragmental soils, with moderately high productivity; slight-to-moderate erosion hazard and equipment restrictions and moderate seedling mortality; suitable for needleleaf and/or broadleaf trees.

WSG-3o2. Soils with moderately high productivity; no serious management restrictions; suitable for needleleaf trees.

WSG-3o7. Soils with moderately high productivity; no serious management problems; suitable for southern hardwoods and/or pines.

WSG-3r8. Loamy soils on steep slopes with moderately high productivity; moderate erosion hazard and equipment limitations; suitable for needleleaf and/or broadleaf trees.

WSG-3w8. Seasonally wet soils with moderately high productivity; moderate equipment limitations and slight-to-moderate seedling mortality; suitable for needleleaf and/or broadleaf trees.

WSG-3x8. Stoney or rocky soils with moderately high productivity; slight-to-moderate erosion hazard and moderate equipment restrictions; suitable for needleleaf and/or broadleaf trees.

WSG-4c3e. Severely eroded soils with moderate productivity; moderate-to-severe erosion hazard, equipment restrictions, and seedling mortality; best suited for needleleaf trees.

WSG-4d3. Moderate depth to shale; woodland restriction because of shallow root depth; severe management problems; best suited for needleleaf trees.

WSG-4x3. Rocky soils with moderate productivity; slight-to-moderate erosion hazard; moderate-to-severe equipment restrictions and seedling mortality; best suited for needleleaf trees.

WSG-5x3. Rocky soils with low productivity; slight-to-moderate erosion hazard; moderate-to-severe seedling mortality and equipment restrictions; best suited for needleleaf trees.

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